REVISION 3

NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 556

HYDRAULIC EQUIPMENT (POWER TRANSMISSION AND CONTROL)

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CHAPTER 556

HYDRAULIC EQUIPMENT (POWER TRANSMISSION AND CONTROL)

SECTION 1.

GENERAL AND SAFETY PRECAUTIONS

556-1.1 GENERAL

556-1.1.1 Hydraulic equipment covered in this chapter includes units for generating force (pumps), piping, and hoses for transmitting fluid under pressure, and components in which the energy in the fluid is converted to mechanical work (cylinders and motors). Also included are valves to control and direct fluid flow and limit pressure, fluid conditioning devices such as filters, coolers, fluid reservoirs, and accumulators for storage of fluid. Hydraulic power transmission and hydraulic control are used in naval applications for a variety of reasons.

a. Among the advantages offered by hydraulic equipment in power transmission and control are that hydraulic power:
   1 Constitutes a functionally simple method of obtaining stepless speed control
   2 Provides for smooth application of varying torque over a wide speed range
   3 Permits flexibility in location of system components
   4 Is readily adaptable to various remote and automatic controls
   5 Allows for effective storage through use of accumulators
   6 Transmits power efficiently and quietly
   7 Affords a high degree of reliability

b. Most of the components used in hydraulic systems have parts that interface with other parts with a sliding or rolling contact. Pistons and spools work in cylinders and bores with extremely small clearances. The hydraulic fluid serves to lubricate bearing areas as well as transmit the energy. Contamination of the fluid with any foreign materials can quickly damage or jam the parts. To obtain the most reliable hydraulic equipment performance, responsible maintenance personnel must ensure that systems:
   1 Are clean when assembled, or when accepting custody of the equipment
   2 Are kept clean
   3 Have the correct amount of the required fluid
   4 Have properly functioning filters
   5 Are correctly adjusted
   6 Are not worked beyond design limits
   7 Do not overheat
   8 Do not leak over allowable limits
   9 Are purged of entrapped air

c. Electrolytically formed anodic coatings on aluminum and aluminum alloys are normally in accordance with MIL-A-8625, Type I, Class 1. Mechanically damaged areas from which the MIL-A-8625 anodic coating has been removed may be repaired and their corrosion resistance restored by Grade B (brush) application of chemical film materials and treatments meeting the requirements of MIL-C-81706.

d. Detailed information on specific hydraulic equipment is available in applicable technical manuals and Maintenance Requirement Cards (MRC's). There are many other books and publications that provide basic information useful in the operation and maintenance of hydraulic equipment. References that are readily available to most naval personnel include:

1 Fluid Power, NAVEDTRA 16193

2 Principles of Naval Engineering, NAVEDTRA 10788

3 Tools and Their Uses, NAVEDTRA 10085

4 Blueprint Reading and Sketching, NAVEDTRA 10077.

5 Lubrication of Ordnance Equipment, NAVSEA OD 3000.

6 SW322-AC-MMA-010, Gun and Missile Launcher Ordnance Systems Hydraulics Manual; Descriptions, Procedures & Instructions for Controlling and Maintaining Cleanliness of Hydraulic Fluids in Gun and Missile Launcher Systems.

556-1.2 SAFETY PRECAUTIONS

556-1.2.1 Unless otherwise stated in maintenance manuals, heed the following precautions when installing, flushing, filling, testing, or performing maintenance on hydraulic piping systems.

a. Before breaking or cutting into a line or disassembling a valve joint, accomplish the following:

  1 If practical, shut down the system and tag system controls to prohibit operation. (Particularly, in the case of large central systems, system shutdown may be impractical under various circumstances).

  2 Isolate the portion of system being worked on by closing all valves; attach warning tags to the valves prohibiting operation. Whenever possible, utilize two-valve protection.

  3 Ensure that the section of system being worked on is completely depressurized and, if possible, drained. If possible, observe the pressure gage and carefully open a drain or vent valve to verify proper operation of isolation valve(s).

  4 Ensure that under no circumstances will hydraulic fluid splash, drip, or spray on electrical and electronic equipment.

b. In breaking flanged joints, ensure that two diametrically opposite securing nuts or bolts remain tight while the remainder are slackened. The two remaining fasteners shall then be slackened just enough to permit breaking the joint and shall be removed only after the joint is broken sufficiently to prove that the line is unpressurized. If possible, the line should be drained before breaking the joint.

c. In the maintenance, disassembly, repair, and testing of hydraulic piping, follow the procedures and precautions set forth in NSTM Chapter 505, Piping Systems .

d. When testing after repairs, take the following precautions:

  1 Use a small-volume, external pressure source (such as a handpump) for hydrostatic tests. If use of an external source is not practical, crack open only the supply valve to the repaired section and continuously man the repair area until the repaired section is proven leak tight.

  2 If fluid spray could damage electrical equipment or create a fire or safety hazard, protect reassembled mechanical joints by covering joints with spray shields (see paragraph 556-3.3).

e. Surface inspect for defects all temporary hoses used for filling, flushing, or testing hydraulic piping systems. Before use, subject temporary hoses to a shop hydrostatic test pressure of at least 110 percent of the maximum pressure to which the hose will be subjected during temporary use on the ship.

f. For electrical equipment safety precautions, refer to For safety precautions regarding phosphate ester based fluids, see paragraph 556-5.1.3.

g. Do not use zinc or cadmium-plated parts in any hydraulic unit where they may come in contact with hydraulic oil. Those coatings react chemically with hydraulic fluid with detrimental results to system operation. This restriction does not prohibit the use of zinc or cadmium-plated parts such as nuts, bolts, and screws in locations that are external to the hydraulic unit if there is no danger of fluid contamination. Wash hands thoroughly after working with cadmium-plated tools or parts to avoid poisoning from ingestion of cadmium-contaminated food.

h. MIL-H-22072 water-glycol hydraulic fluids may contain nitrites and amines that may form nitrosamines that constitute a potential carcinogenic hazard. MIL-H-19457, phosphate ester based hydraulic fluids contain a controlled amount of toxic material. Contact with both these fluids should be avoided. For specific precautions and for information regarding protective gear (such as gloves, boots, aprons, coveralls, and face masks), available for system maintenance and for working in areas where a visible fluid mist is present or a fluid spill has occurred, see paragraph 556-5.2. Thoroughly clean skin areas contaminated with fluid with soap and water. Flush eyes with running water for at least 15 minutes, and immediately remove and launder contaminated clothing. Report each case of contamination to local medical representatives.

i. On all systems containing MIL-H-22072 or MIL-H-19457 fluids, post a label or instruction plate identifying the fluid contained in the system, routine safety precautions, and decontamination procedures.

j. Observe all precautions to prevent fluid ignition or explosion during handling and stowage. See NSTM Chapter 670, Stowage, Handling, and Disposal of Hazardous General Use Consumables .

k. Observe the following safety rules during the use or storage of cleaning agents for hydraulic components. For additional general information on solvents, see paragraphs 556-8.12 through 556-8.13.

1 Provide adequate ventilation.

2 Always store new or used solvents in clearly labeled containers.

3 Provide eye flooding and shower facilities as needed.

4 Keep containers sealed when not in use.

5 Avoid prolonged or repeated contact with the skin or breathing of vapors.

6 Prohibit smoking, welding, or use of open flame in the vicinity of volatile or flammable solvents. Keep temperatures well below the flashpoint.

7 Dispose of contaminated solutions in accordance with local safety regulations.

8 Do not take solvents internally.

9 Use protective devices such as cover or cup-type goggles, face shields, solvent resistant gloves, and other protective clothing, as required.

556-1.3 LIFE CYCLE MANAGERS (LCM′s) AND IN-SERVICE ENGINEERING AGENTS (ISEA′s) FOR HYDRAULIC SYSTEMS

556-1.3.1 NSTM CHAPTER 556 AND GENERAL SHIPBUILDING SPECIFICATIONS. Within the Naval Sea Systems Command (NAVSEA), SEA 03W15 has technical responsibility for this chapter of the NSTM and the Section 556 Hydraulic Power Transmission Systems of the General Shipbuilding Specifications and the Shipbuilding Specifications for specific ships. Other specification sections may also contain hydraulic requirements for specific systems. These other specifications are usually the responsibility of the cognizant system LCM as listed in Table 556-1-1. Component specifications are the responsibility of the cognizant equipment LCM as listed in Table 556-1-2.

Table 556-1-1. NAVSEA AND PSNSY LIFE CYCLE MANAGER (LCM) RESPONSIBILITY FOR HYDRAULIC SYSTEMS AND COMPONENTS

Ship System	Code
Submarines	
All Central Systems (Includes Ship Service,	03W15
External, Main-Vital, Mission Launching)	03W15
Steering, Diving	
Other Independent Systems	*
Surface Ships	
Anchor Handling	03W22
Boat Handling	03W22
Catapult and Arresting Gear	NAVAIR
Central Including Ship Control (Steering)	03J1
Central (Not Including Ship Control)	**
Controllable Pitch Propeller	03X72
Crane	03W43
Elevators, Aircraft & Weapon	03W43
Fin Stabilizers	03J1
Jet Blast Deflectors	NAVAIR
LSO Platform	NAVAIR
Minesweeping	03W22
Ocean Engineering & Handling Systems	03W22
Powered Doors and Hatches	03W21
Stabilized Guide Slope Indicators	NAVAIR
Towed Body Handling Systems	03W22
Underway Replenishment	03W24
Valve Actuation (Cargo Fuel, and JP-5)	PSNSY 260.4
Valve Actuation (Ballast and Firemain Systems)	PSNSY 260.4
Valve Actuation (Deballast - Air System)	PSNSY 260.4
(Non-standardized components for the previously listed valve actuation systems)	PSNSY 260.4
Weapon Systems	*

* System LCM generally belongs to Code responsible for the equipment being actuated.

**System LCM generally belongs to Code responsible for the greatest hydraulic load on the system.

Table 556-1-2. NAVSEA AND PSNSY LCM CODES FOR HYDRAULIC COMPONENT SPECS

MIL-V-868	Valve, Directional Control	03W15
MIL-V-1189	Valve, Gate	PSNSY 260.4
MIL-C-15730*	Coolers	03X43
MIL-P-17869*	Pumps & Motors, Hydraulic	03W4
MIL-V-18110	Valve, Gate	PSNSY 260.4
MIL-V-18436	Valve, Check	PSNSY 260.4
MIL-V-22052	Valve, Globe	PSNSY 260.4
MIL-V-22687	Valve, Ball	PSNSY 260.4
MIL-V-24109	Valve, Globe	PSNSY 260.4

Table 556-1-2. NAVSEA AND PSNSY LCM CODES FOR HYDRAULIC COMPONENT SPECS - Continued

MIL-F-24402	Filters, Filter Elements	03W15
MIL-A-24533	Rotary Actuators	03W15
MIL-V-24630	Check Valves	03W15
MIL-V-24695	Valve & Hose Assembly	03W15
MIL-F-24702	Filter Elements, Disposable	03W15
MIL-F-24704	Flange, Four Bolt Square	03W15
MIL-C-24706	Coupling, Pipe, Heat-Removable	PSNSY 260.4
MIL-C-24714	Transfer Tube, Hydraulic	03W15
MIL-V-24722	Servo Flow-Control, Electrohydraulic	03W15
MIL-F-24724	Filter Housings	03W15

* Lacks configuration control

556-1.3.2 SYSTEM LCM'S AND ISEA'S. Life Cycle Managers (LCM′s) for many shipboard hydraulic systems are identified in Table 556-1-1. Assigned engineering and technical management functions for ship systems, equipments, and components are performed for the LCM′s by In-Service Engineering Agents (ISEA′s). See NAVSEA Publication S0300-A9- MAN-010 for a listing of LCM′s and ISEA′s for Hull, Mechanical and Electrical Systems for which SEA 03 has cognizance.

556-1.3.3 COMPONENT RESPONSIBILITY. The LCM responsible for a hydraulic system is responsible for the components within the system except for:

a. Standard components covered by a Military Specification with configuration control or by a Navy Standard Drawing. Responsibility for these standardized components belongs to the cognizant technical code as identified in paragraphs 556-1.3.3.1 through 556-1.3.3.3. When a component is permitted to deviate from Military Specification requirements, the system LCM is usually responsible for the component.

b. Non-standard hydraulic actuators (motors, cylinders, etc) are the responsibility of the activity responsible for the equipment or system being actuated. (For central hydraulic systems as on submarines, cognizance of the equipment being operated may be the responsibility of several different codes and activities.)

556-1.3.3.1 Component Military Specifications Prepared by NAVSEA. For specifications with configuration control (usually accompanied by specification part numbers) the LCM responsibility belongs to the code responsible for the specification. For military specifications without specific performance (speed, flow, capacity, pressure, etc.) or configuration control requirements, it is the responsibility of the system LCM to establish these requirements. For these components without complete specification requirements, problems should first be referred to the system LCM or the applicable ISEA. The cognizant NAVSEA Codes for NAVSEA prepared hydraulic component specifications are listed in Table 556-1-2.

556-1.3.3.2 Component Military Specifications Not Prepared by NAVSEA. SEA 03W15 will exercise NAVSEA technical coordination for components to Military Specifications and Standards prepared by other activities, if the component specifications are listed for Hydraulic Service in MIL-STD-438, MIL-STD-777, or Section 556 of the Shipbuilding Specifications. Some frequently used specifications currently in this category are:

MIL-F-5504 **Filter and Filter Elements**

MIL-V-8813 **Relief Valves**

MIL-F-8815 **Filters and Filter Elements**

MIL-V-81940 **Sampling Valves**

For components to specifications not listed, the code responsible for the system has responsibility for any necessary technical coordination with the specification preparing activity.

556-1.3.3.3 Components to Standard Drawings. For components to standard drawings, LCM responsibility belongs to the code (activity) responsible for the drawing. For most valves and fittings this is Puget Sound Naval Shipyard (PSNSY) Code 260.4. NAVSEA 03L (formerly 05Y) still retains life cycle system responsibility and interface responsibility.

556-1.3.4 ORDERING MILITARY AND INDUSTRY DOCUMENTS. A number of military and industry documents such as specifications, standards, handbooks and information reports are referenced herein. Many activities have direct access to these documents by way of CD ROM or other means. If direct access is not available, documents may be ordered as described below.

556-1.3.4.1 Military Documents. Order from:

DODSSP

Subscription Service Desk

700 Robbins Avenue, Bldg. 4D

Philadelphia, PA 19111-5094

Telephone (215) 697-2569, DSN 442-2569

Monday - Friday: 8AM - 4:30PM

The fastest way to obtain documents is through Telespecs which is your direct connection to the Navy Print on Demand System. Telespecs requires only a touch-tone phone and has 12 lines open from 7 AM to 10 PM Monday through Friday at (215) 697-1187/1198 or DSN 442-1187/1198. To use Telespecs you must have a customer number which may be obtained from the DODSSP Special Assistance Desk, (215) 697-2667/2179 or DSN 442-2667/2179. Mail orders may be submitted on DD Form 1425 or company letterhead.

556-1.3.4.2 Industry Documents. Military activities may use the procedures above to order Non-Government or Industry documents which have been adopted by DOD and are stocked at DODSSP. Private industry must order these documents from the preparing technical societies. (Industry documents referenced in NSTM Chapter 556 are usually DOD adopted except in the case of ISO standards.)

SECTION 2.

PUMPS, MOTORS, AND ACTUATORS

556-2.1 HYDRAULIC PUMPS

556-2.1.1 GENERAL. The heart of any hydraulic system is the pump. The pump converts mechanical energy into hydraulic energy for further distribution, control, and application.

a. The basic types of hydraulic pumps used on Navy ships are:

1 Vane

2 Piston

3 Gear

4 Screw

b. Each of the four basic type pumps listed in (a) has one or more characteristics to make it desirable for use in some specific application. These characteristics will be discussed in paragraphs 556-2.1.2 through 556-2.1.5.1. All pumps need a clean fluid having adequate lubricating qualities. All must be designed, installed, and operated so as to allow the flow of fluid into the suction side of the pump with minimum restriction. If inlet strainers are clogged, inlet passages restricted, pumps run too fast, or if the fluid is not of correct viscosity to flow freely, the pump may cavitate. This is the condition where atmospheric pressure, or in some cases the supercharging pressure, that is causing the fluid to flow into the pump inlet is not sufficient to completely fill each cavity of the unit as the pump shaft revolves. In this case, a void forms in the cavity, rather than a solid charge of fluid. When the pump cavity progresses to the position where it is opened to the high pressure outlet port, the high pressure fluid immediately fills the void, or fluid vapor pocket, with an impact that produces a damaging shock and vibration and an audible noise. A pump being operated in a cavitating condition will generally fail completely in a fairly short time.

c. Before starting the power source which drives the pump of a hydraulic system, particularly if the unit is new, just repaired, or if it has not been operated for a long time, observe the precautions in c.1 through c.7.

1 Be sure the internal parts of the pump are lubricated by flooding the pump intake (for piston pumps also fill the pump case) with clean fluid of the type used in the system.

2 Turn over the pump by hand or with a turning bar or wrench to ensure that the unit turns freely.

3 Check the reservoir or service tank to ensure that the fluid is at the correct level.

4 Check to ensure that there are no closed valves or other blockages which will prevent the pump from drawing fluid into the inlet side.

5 Determine that pressurizing of the system will not cause undesired movement or action in some other part of the system.

6 Jog the drive unit and determine that the pump will be driven in the correct direction.

7 Be sure that the elements installed in the system filters are clean.

d. Immediately after starting the pump of a hydraulic system, observe procedures in d.1 through d.5:

1 Listen for unusual or excessive noise.

2 Check for any leaks.

3 After several minutes of operation, feel the pump case in several places to check if there is any unusual heating which may indicate trouble.

4 Check to ensure that system pressures are normal.

5 Check the fluid level in the service tank.

e. If, after observing all the above precautions, a pump fails to deliver fluid, or does not develop the required pressure, one or more of the deficiencies in e.1 through e.5 may be the cause:

1 Air is leaking into the intake line or intake port.

2 Unusual conditions may have made the fluid too thick to flow freely

3 The pump is severely worn internally.

4 There may be broken parts in the pump.

5 The direction of rotation label may be in error and the pump installed to conform to the label.

f. Unsatisfactory performance or unusual vibration or noise that can definitely be attributed to the pump is generally adequate evidence that the pump requires repair. Specific pump technical manuals or system manuals should be referred to for instructions for diagnosing trouble and for repair procedures.

556-2.1.2 VANE PUMPS. Vane-type hydraulic pumps generally have a housing or casing with the interior circular or elliptically shaped and a flat end plate on the front and back. A slotted rotor is affixed to a shaft which enters the housing cavity through one of the end plates. A number of small rectangular plates or vanes are set into the slots of the rotor in such a manner that they can slide in and out of the slots radially. As the rotor is turned, the outer edge of each vane slides along the surface of the housing cavity and the vanes slide in and out of the rotor slots. The numerous cavities, formed by the vanes, the end plates, the housing and rotor, enlarge and shrink as the rotor and vane assembly rotates. An inlet port is installed in the housing so that fluid may flow into the cavities as they enlarge. An outlet port is provided to allow the fluid to flow out of the cavities as they become small.

a. Figure 556-2-1 illustrates the basic configuration of a simple vane pump.

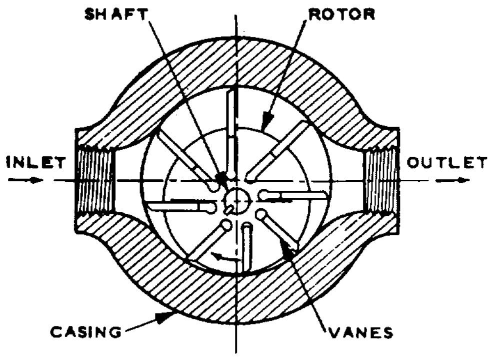


Figure 556-2-1. Vane Pump

b. The vane pump is relatively low priced, is very efficient, and is small and compact for its pumping capacity. Usually vane pumps are fixed displacement and pump in one direction. There are designs of vane pumps which provide variable flow but these are rarely used in Navy shipboard applications. Vane pumps are generally restricted to service where pressure demand does not exceed 2000 lb/in^2 . Wear rates vibration, and noise levels increase rapidly in vane pumps as pressure demands exceed 2000 lb/in^2 .

c. Problems that may be experienced with vane pumps which are not applicable to other types of pumps are associated with the vane and rotor assembly. The vanes are a very close fit in the slots of the rotor. Any burrs on the surfaces, or particulate contamination between the parts, will tend to cause the vanes to stick in the retracted position. Springs are generally installed under the vanes to ensure a good contact between the vane and the housing surface. These springs may break and jam the vane in the slot. A broken spring will also reduce the effectiveness of the seal between the vane and housing, causing excessive internal leakage. The surfaces where the vanes rub may wear, particularly at the point where the vanes are being forced back into the rotor slot. Most problems with vane pumps will be evidenced by excessive noise and reduced performance.

556-2.1.3 PISTON PUMPS. Piston pumps are made in a variety of types and configurations. A basic distinction is made between axial and radial pumps. The axial piston pump has the cylinders parallel to each other and the drive shaft. The radial piston design has the cylinders extending radially outward from the drive shaft like the spokes of a wheel. A further distinction is made between pumps which are fixed delivery and those able to vary the flow of the fluid. Variable delivery pumps can be further divided into those able to pump fluid from zero to full delivery in one direction and those able to pump from zero to full delivery in either direction of flow.

a. All piston pumps used in Navy shipboard systems have the cylinders bored in a cylinder block which is mounted on bearings within a housing. This cylinder block assembly rotates with the pump drive shaft. In axial piston pumps of the in-line type, where the cylinders and the drive shaft are parallel, the reciprocating motion is imparted to the pump pistons by a cam plate, also known as a wobble plate or swash plate. This plate lies in a plane which cuts across the centerline of the drive shaft and cylinder barrel and does not rotate. In a fixed displacement pump, the cam plate will be rigidly mounted in a position so that it intersects the centerline of the cylinder barrel at an angle approximately 25 degrees from perpendicular. Variable delivery axial piston pumps are designed so that the angle which the cam plate makes with a perpendicular to the centerline of the cylinder barrel may be varied from zero to 20 or 25 degrees to one or both sides. Figure 556-2-2 illustrates the in-line type axial piston pump. One end of each piston rod is held in contact with the cam plate as the cylinder block and piston assembly rotates with the drive shaft. This causes the pistons to reciprocate within the cylinders with a stroke proportional to the angle that the cam plate is set from perpendicular to the centerline of the cylinder barrel.

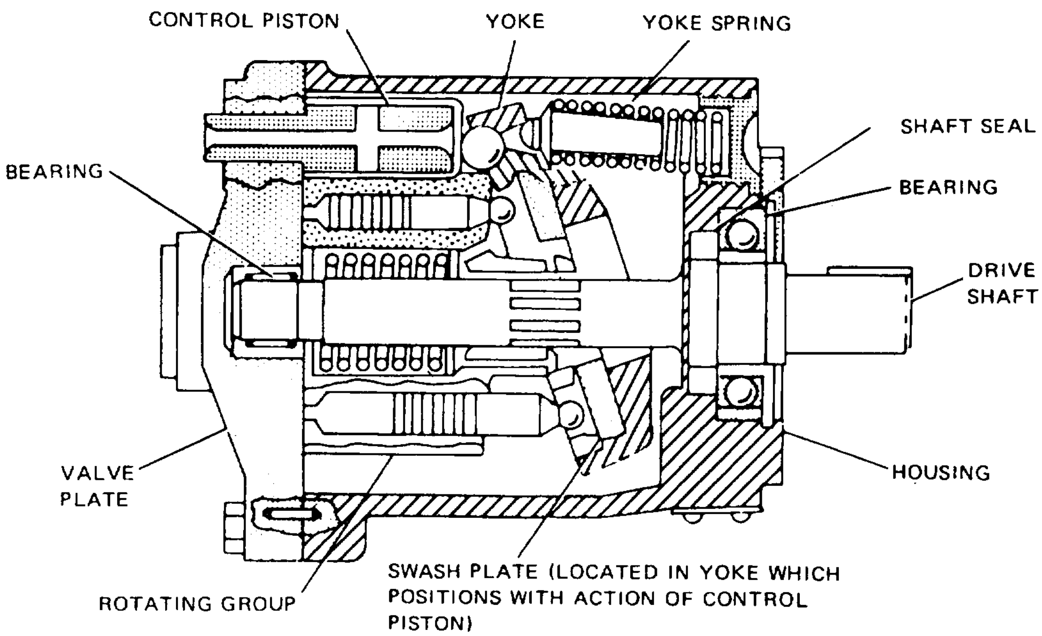


Figure 556-2-2. In-Line Type Axial Piston Pump

b. A variation of axial piston pumps is the bent-axis type shown in Figure 556-2-3. This type does not have a tilting cam plate as the in-line pump does. Instead, the cylinder block axis is varied from the drive shaft axis. The ends of the connecting rods are retained in sockets on a disc which turns with the drive shaft. The cylinder block is turned with the drive shaft by a universal joint assembly at the intersection of the drive shaft and the cylinder block shaft. In order to vary the pump displacement, the cylinder block and valve plate are mounted in a yoke and the entire assembly is swung around a pair of mounting pintles attached to the pump housing.

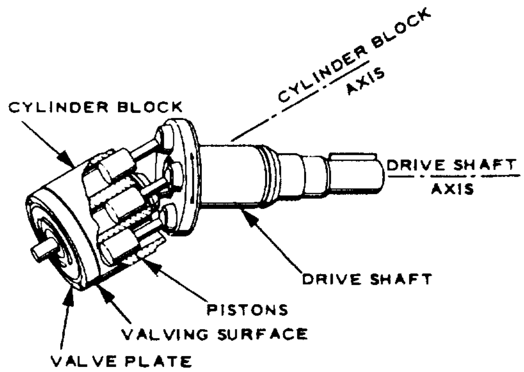


Figure 556-2-3. Bent-Axis Type Axial Piston Pump

c. In variable displacement radial piston pumps, the reciprocating motion is imparted to the pistons by a cam ring or rotor which encircles the cylinder and piston assembly. The rotor is mounted in a slider block within the pump case in such a way that it will rotate with the cylinder block and also may be moved back and forth in a plane perpendicular to the axis of rotation of the cylinder block. The outer end of each piston rod is held in contact with the rotor as the assembly turns. When the rotor is concentric with the axis of the cylinder barrel, there will be no reciprocating motion of the pistons as the rotating group turns. When the cam ring is moved to the side so its center point is no longer concentric with the cylinder and piston assembly, the pistons will then reciprocate within the cylinder barrel as the rotating group turns. The amount of piston stroke will be proportional to the amount of displacement of the rotor. Figure 556-2-4 illustrates the radial piston pump design. Most variable delivery pumps have hydraulic servo assist mechanisms to position the wobble plate, yoke, or rotor as the forces on these elements are quite large and positioning must be very accurate.

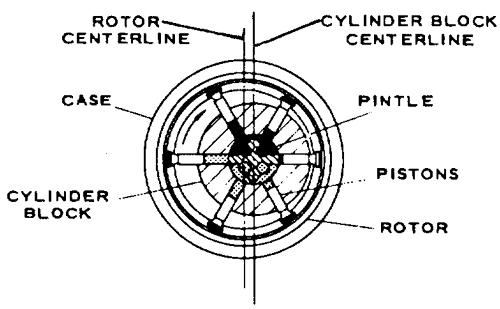


Figure 556-2-4. Radial Piston Pump

d. Piston pumps must have a means for fluid to enter and leave the cylinders. In axial piston pumps of the in-line type, one end of the cylinder block turns against a stationary valve plate. The valve plate has holes located so that for one-half revolution of the cylinder block there is a passage from one particular cylinder to a port leading to external pipe connections. For the other half revolution, the cylinder has access through another passage to a second port leading to a second external pipe connection. For the half revolution of the rotating group, while the piston is traveling away from the valve plate, a cylinder will draw in fluid from the low pressure port. As the piston reaches the maximum retracted position, the cylinder opening passes to the other opening in the valve plate so that as the piston is moved toward the valve plate during the next half revolution the fluid is forced out the high pressure port. In axial piston pumps of the bent axis type, the fluid passes through passages in the pintles, yoke, and valve plate to enter and leave the cylinders. In a radial piston pump, the valving function is accomplished by a stationary hub or pintle at the center of the rotating cylinder block. The radial cylinders have openings at the inner bore of the cylinder block. This cylinder block bore fits closely on the pintle. The pintle has a passage, that leads to an external connection, around one-half the area that contacts the cylinder block. The other side of the pintle has passages that connect to another external connection.

e. Piston pumps are highly efficient and comparatively rugged units. Pressure capabilities may range to 6000 lb/in^2 or more. Their adaptability to providing bi-directional, variable flow is the reason piston pumps are used almost exclusively for power transmission systems larger than ten horsepower on surface ships. The disadvantages of piston pumps are higher cost, greater weight, and larger size for a given capacity than vane or gear pumps.

f. Piston pumps have numerous sliding and rolling contact bearings which are easily damaged by contamination. Special care should be given to ensure that fluid is kept clean in these systems. Bearings within the pump depend upon fluid in the pump case for lubrication. Piston pumps should never be started with the pump case empty. If piston pumps are relocated from their original installation, always make certain that the case drain line going back to the service tank comes off the top of the pump so that the case remains full of fluid. If a piston pump cavitates upon start-up, stop the unit immediately and correct the cause of the cavitation. Generally the trouble will be a restricted inlet to the pump. Strainers may be clogged, valves closed, fluid level in the service tank may be too low, or the fluid may be too viscous for the conditions. If repairs are made to piston pumps, be particularly careful of the valve plates and cylinder block face. The seal made by these mating surfaces has a major effect on the efficiency of the pump. Variable delivery pumps should not be run in the zero delivery position for extended periods of time. There is no flow of fluid through the valve plate in the zero delivery position and excessive heating of the valve plate may occur. Navy approved pumps are required to be able to withstand one-half hour of running at zero delivery without damage. However, it is desirable to avoid running at zero delivery for more than a few minutes when operating the equipment.

556-2.1.4 GEAR PUMPS. Gear pumps are seldom used on Navy shipboard equipment as the main pump in a power transmission system. However, there are many applications of gear pumps as auxiliary pumps: to provide fluid for replenishing main systems, to supercharge larger piston pumps, to provide fluid pressure for servo mechanisms for control of large pumps, and for fluid transfer. In its simplest form, a gear pump is a pair of gears in mesh and fitted closely into a housing around the periphery of the gears and on the sides. Figure 556-2-5 shows the basic configuration of this type pump. Fluid ports are provided on each side of the point where the gears mesh. When the gears turn, fluid fills each cavity between the gear teeth as the teeth separate at the point of mesh (area A of Figure 556-2-5). The fluid in this cavity then is carried by the gear teeth nearly a complete revolution until a gear tooth of the mating gear forces the fluid out of the cavity at the point of mesh (area B of Figure 556-2-5). The fluid then is forced out of the outlet port. There are other designs of gear pumps such as those with internal and external gears and those with lobes in place of gears. These types are not used very extensively in Navy shipboard systems.

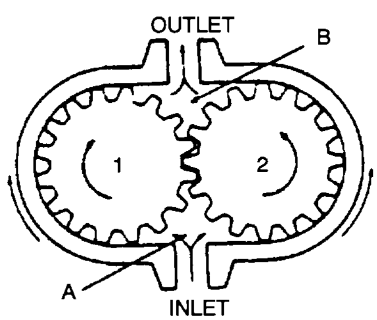


Figure 556-2-5. Gear Pump

a. The gear pump is the lowest priced and simplest of the pumps used in hydraulic systems. It is generally able to pump contaminated fluid with less damage than other pumps and will rarely fail instantly as vane, piston, and screw pumps occasionally do. The efficiency of gear pumps is generally low. Most gear pump applications are for low pressure, 600 lb/in^2 or less, as internal leakage increases rapidly at the higher pressures.

b. When repairing gear pumps, the clearance between the gear teeth and at the sides of the gears is very critical. Part dimensions and operating clearances must be held to recommended values to ensure satisfactory operation. Correct alignment when installing gear pumps is very important. Generally gear pumps do not have the heavy duty bearing assemblies used in vane and piston pumps and a side force on the pump shaft may cause rapid wear of the gears or case.

556-2.1.5 SCREW PUMPS. Screw pumps for power transmission systems are generally used only on submarines. Although low in efficiency and expensive, the screw pump is suitable for high pressures (3,000 lb/in^2), and delivers fluid with little noise or pressure pulsation. Screw pumps identified herein are manufactured and supported by the IMO Pump Division of IMO DeLaval Inc. (CGEC 59180). Table 556-2-1 reflects submarine hydraulic system usage. Figure 556-2-6 illustrates the screw pump.

Table 556-2-1. SCREW PUMP SERIES NOW IN SERVICE (SUBMARINES)

Ship/Class	**Main**	**Vital**	**Lead**	**External**	**Steering**	**Diving**	**Technical Manual(s)**
AGSS 555					31K x 137	31K x 137	0322-037-5010
SS 576	31K-137	31K-137	31K-137	31K-137			0347-274-0000
SS 580 CL	31K-156	31K-156	31K-156				0322-032-4005
SSN 575	31K-187(2)	31K-187		31K-187	31K-187(2) B & S		0347-187-5000
SSN 578 CL	31K-118	31K-118	31K-118	31K-118			0347-290-6000
SSN 585 CL	31K-137	31K-137	31K-137	31K-137			0347-343-1000 or 0347-309-8000
SSN 594	31K-156	31K-156	31K-156(2)				0347-337-7000
SSN 594 CL less 594, 603, 604 & 612	31K-187	31K-187	31K-156(2)	31K-137			0347-383-7000 & 0321-005-1000
SSN 597	31K-156	31K-156	31K-156				0347-319-1000
SSN 603, 604, & 612	31K-187	31K-187	31K-156(2)	31K-156			0347-383-7000 & 0321-005-1000
SSN 608 CL	31K-156	31K-156	31K-156(2)	31K-137(2)			0347-432-3000 & 0347-365-7000
SSN 637 CL	31K-200	31K-200	31K-200	6DBX-156(2)			0347-431-1002
SSN 671	31K-200	31K-200	31K-200	6DBX-156(2)			0947-095-4010
SSN 685	31K-200	31K-200	31K-200	6DBX-156(2)			0947-095-4010
SSBN 616 CL	31K-200	31K-200	31K-200(2)	31K-137(2)			0347-405-7000
SSBN 640 CL	31K-200	31K-200	31K-200	6DBX-156(2)			0347-405-7000
Ship/Class	Starboard	Port	Lead	External	Steering	Diving	Technical Manual(s)

Table 556-2-1. SCREW PUMP SERIES NOW IN SERVICE (SUBMARINES) - Continued

Ship/Class	Main	Vital	Lead	External	Steering	Diving	Technical Manual(s)
SSN 688 CL	31K-200	31K-200	31K-200		31K-200	31K-200	0947-200-6010
SSBN 726 CL	31K-200(2)	31K-200(2)	31K-200(2)			31K-200(2)	947-LP-241-7010
NOTE: Quanitity of each pump in a particular service is indicated in parentheses.							

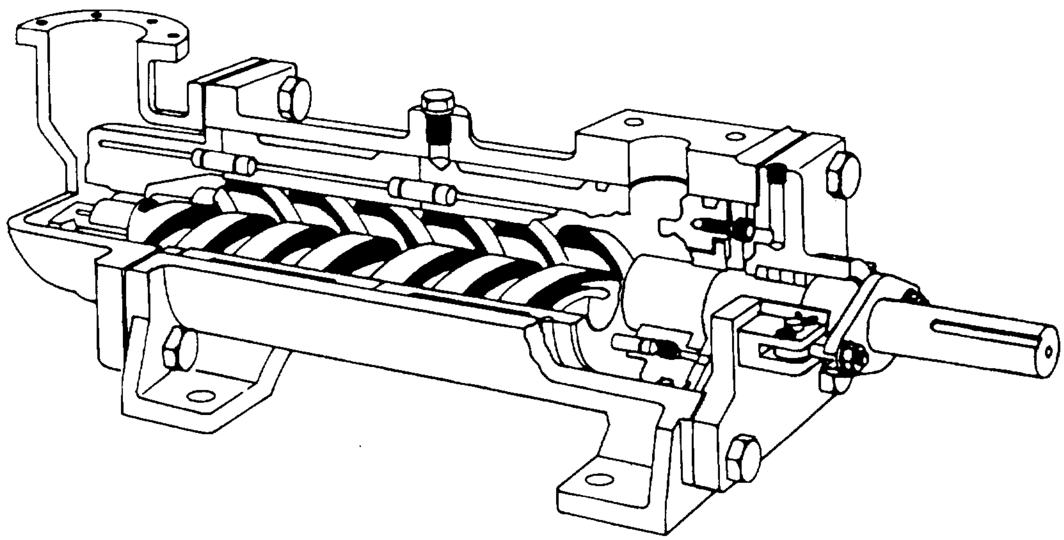


Figure 556-2-6. Screw Pump

556-2.1.5.1 Screw Pump General Characteristics. Subparagraphs a. through f. describe the general characteristics of screw pumps.

a. Operation. In a fixed-displacement rotary-type screw pump (see Figure 556-2-6), fluid is propelled axially in a constant, uniform flow through the action of just three moving parts - a power rotor and two idler rotors. The power rotor is the only driven element, extending outside the pump casing for power connections to an electrical motor. The idler rotors are turned by the power rotor through the action of the meshing threads. The fluid pumped between the meshing helical threads of the idler and power rotors provides a protective film to prevent metal to metal contact. The idler rotors perform no work, so the rotors need not be connected by gears to transmit power. The enclosures formed by the meshing of the rotors inside the close clearance housing contain the fluid being pumped. As the rotors turn, these enclosures move axially providing a continuous flow. Effective performance is attributable to:

1 The rolling action obtained with the thread design of the rotors is responsible for the very quiet pump operation. The symmetrical pressure loading around the power rotor eliminates the need for radial bearings as there are no radial loads. The cartridge-type ball bearing in the pump is to position the power rotor for proper seal operation. The axial loads on the rotors created by discharge pressure are hydraulically balanced.

2 The key to screw pump performance is in the operation of the idler rotors in their housing bores. The idler rotors generate a hydrodynamic film to support themselves in their bores like journal bearings. Since this film is self-generated, it is dependent on three operating characteristics of the pump: speed, discharge pres-

sure, and fluid viscosity. The strength of the film is increased by increasing the operating speed, by decreasing pressure or by increasing the fluid viscosity. This is why screw pump performance capabilities are based on pump speed, discharge pressure, and fluid viscosity as indicated on the individual pump outline drawings.

b. Efficiency. Screw pumps are not as volumetrically efficient as piston pumps. The efficiency when compared after both pump types have been broken in would be approximately 90 percent for the piston and 75 percent for the screw pump. The decreased efficiency requires higher horsepower motors and attending electrical controls. However, the lower efficiency is compensated for by quiet operation, reliability, and ease of repair compared to piston pumps.

c. Pressure Control. Positive displacement pumps provide a flow of oil to a system which may consist of valves and a hydraulic cylinder or hydraulic motor. Restrictions to this flow such as the resistance to movement of a hydraulic cylinder or resistance to turning of a hydraulic motor develop pressure. This is reflected in the pump as discharge pressure or load. A positive fixed displacement pump should never be installed without a relief valve to limit the pressure developed by the pump.

d. Fluids. The fluids used for 3,000 lb/in^2 submarine hydraulic systems are usually symbol 2190-TEP in conformance with MIL-L-17331. One of the three viscosities of fluids available under MIL-L-17672 (symbols 2075TH, 2110TH, 2135TH) are used for lower pressure applications. At high pressures and temperatures, a more viscous fluid is required for efficient pump performance. Table 556-2-2 indicates the flow capacity of various screw pumps at several temperatures and pressures with the most commonly used fluids. When a flow rating is not provided in the table for a specified set of temperature and pressure conditions, NAVSEA should be consulted before operating a pump under these conditions.

Table 556-2-2. SCREW PUMP CAPACITY BASED ON FLUID AND R/MIN

			Gal/Min @ 1,750 R/Min				Gal/Min @ 3,500 R/Min			
Temp*°C(°F)	**DeLavalPump**	**1b/in^2**	**2190TEP**	**2135TH**	**2110TH**	**2075TH**	**2190TEP**	**2135TH**	**2110TH**	**2075TH**
54 (130)	31K-200	1,500	43	41	40		97	95	94	
54 (130)	31K-200	3,000	39-1/2	36			93	91		
54 (130)	31K-187	1,500	35	33-1/2	32		80	78	77	
54 (130)	31K-187	3,000	31	28			76	74		
54 (130)	31K-146	1,500	19	18	17	15-1/2	45	44	42-1/2	41
54 (130)	31K-156	3,000	16-1/2	14-1/2			42	40	38-1/2	
54 (130)	31K-137	1,500	12-1/2	11-1/2	11	10	30	29	28	27
54 (130)	31K-137	3,000	10-1/2	9			28	26-1/2	25	
54 (130)	6DBX-156	1,500	16				38			
38 (100)	31K-200	1,500	47	45	43	40-1/2				
38 (100)	31K-200	3,000	44	42	39					
38 (100)	31K-187	1,500	38-1/2	37	35	32-1/2				
38 (100)	31K-187	3,000	36	34	31					
38 (100)	31K-156	1,500	21-1/2	20-1/2	19	17-1/2	47	46	45	44
38 (100)	31K-156	3,000	20	18-1/2	16-1/2		45	43-1/2	42	
38 (100)	31K-137	1,500	14-1/2	13-1/2	12-1/2	11				
38 (100)	31K-137	3,000	13	12	10-1/2					
38 (100)	6DBX-156	1,500	19-1/2	17-1/2	16	14-1/2	41			

e. Refer to individual ship system diagrams for operating temperature limitations.

e. Suction Lift Capability. Screw pumps have the capability to pull a suction at the pump inlet. The amount of suction, measured in inches of mercury, is a variable dependent on pump series, oil viscosity, and pump speed. In order to be sure a pump will operate satisfactorily and not have to rely upon the suction lift variables, the vent and supply tank are usually pressurized and the oil level in the tank is brought above the pump inlet. Several earlier submarines have the vent and supply tank located below the pump, therefore retention of the air pressure is very important. In the event the air pressure is lost, the pumps will burn out rapidly even if they tend to have good suction capabilities as the frictional losses in the pipes, fittings, filters, and valves in the suction pipe-run will exceed the suction capability of the pump. Systems with the tank mounted above the pump tend to provide some increased degree of safety in the event the air pressure is lost; however, the pipe losses that are encountered between the tank and the pump may negate the apparent gains. The most reliable configuration is one that utilizes the pump immersed in the tank. Here the air pressure is still required for best pump life; however, under an emergency condition the pump may be expected to run without major trouble although noise levels may increase.

f. Maintenance. General maintenance and start-up guidelines for screw pumps are:

1 Disassembly. To disassemble the pump, sufficient space is needed to withdraw the power rotor from the coupling end of the casing, and the idler rotors (and if necessary, the rotor housings) from the outboard end. The simpler method of preparing for disassembly is to break the coupling joint and the pipe connections, and lift the pump clear of its seating for free access to all parts. Before dismantling, always refer to the applicable technical manual prepared for that specific pump as well as any Technical Repair Standard (TRS) that is applicable.

2 Startup. Before starting for the first time, the prime mover should be checked to verify that it has been wired for rotation in the direction indicated by the arrow on the pump casing. The pump should be primed. This is accomplished, when the suction is under pressure, by opening the suction valve and venting the discharge by removing one of the pipe plugs on the side of the outlet port. If the pump is not under pressure, it may be primed by removing one of the pipe plugs on the side of the inlet port, and pouring in some clean hydraulic fluid.

3 Alignment. When reinstalling a screw pump into its operating position, the alignment with the driving motor-shaft is extremely critical. A slight misalignment or side force on the pump shaft may cause a premature failure. Refer to the pump technical manuals for alignment tolerances and procedures.

4 Leakage Criteria Pump Shaft Mechanical Seal. For screw pumps used in hydraulic systems, a leakage at the mechanical shaft seal of up to five drops an hour is acceptable; shaft seal replacement is recommended whenever leakage exceeds this value. During replacement of mechanical shaft seals, the power rotor shaft in the area of the seal and the stationary element sealing surface shall be inspected. Any pitting, scoring, or scratches are cause for rejection as leakage will occur if these surfaces are not free of defects.

5 Alternate Use of Pumps. On board submarines of the SSBN608, SSBN616, SSBN640, and SSN637 Classes, and on SSN671 and SSN685, the external hydraulic power plant has two identical electric-motor-driven pumps. One pump is selected for normal automatic ON and OFF operation while the other pump is OFF and is selected for operation only in event of a casualty or performance of maintenance on the normally operating pump. Examination of pumps during overhaul indicates that during long periods of inactivity water particles may penetrate the protective oil film on pump internals and cause corrosion. To prevent corrosion of pump internals the pump selected for normal operation should be alternated at least once a week.

NOTE

Quanity of each pump in a particular service is included in parentheses.

556-2.1.5.2 31K-200 Series Screw Pump Characteristics. This paragraph (and subparagraphs) discusses the 31K-200 series of screw pumps which have been through a number of design developments. The original pump designs used on SSBN616, SSBN640, and SSN637 Class ships were simply identified as 31K-200 although they differed in configuration as indicated in Table 556-2-3. Subsequent design configuration pumps have been designated with prefixes A, B, and C to indicate differences in construction. Table 556-2-3 identifies in a matrix format the various pump models, ship applicability, whether or not the pump is installed in the supply tank, and applicable outline and assembly drawings. Specific pumps of this series which are currently in use are discussed in the following subparagraph.

Table 556-2-3. 31K-200 SERIES PUMP INSTALLATIONS

Ship/Class	Pump Model	Outline Dwg	Assembly Dwg	Manifold Dwg		Design Features, Remarks
				Welded (No Cover)	Cast (With Cover)	
SSBN616 Class	31K-200	SG 4045 SG 4200 SG 4214	SG 4435	SG 4164	SG 4438	Pump installed external to tank. Most pumps originally installed had welded manifold. Cast manifold is subject to bolt failure.
	C31K-200	SF10414	SF 10422		SF 10402 & SF 10407	Replacement pump for SSBN616 Class.
SSN637 Class	31K-200	SG 4384 SG 4387	SG 4381		SG 4380	Pump installed in tank. Subject to manifold bolt failure.
SSBN640 Class	31K-200	SG 4289 SG 4389 SF 10204 SG 4388 SG 4290 SG 4520	SG 4381 SG 4381 SG 4381 SG 4381 SG 4518	SG 4164 SG 4164 SG 4164	SG 4380 SG 4350 SG 4380 SG 4380 SG 4438 SG 4438	Pump installed in tank. Manifolds with cast cover, subject to bolt failure. Pumps interchangeable with those on SSN637 Class, SSN671 and SSN685.
SSN671	31K-200	SG 4477	SG 4381		SG 4380	Pump installed in tank, subject to manifold bolt failure.
SSN685	31K-200	SG 4738	SG 4381			
SSN637 & SSBN640 Classes, SSN671 & SSN685	A 31K-200	SG 4813	SF 10332		SF 10402 & SF 10407	Replacement or modified pump with improved attenuator manifold.
SSN688 CL	B 31K-200	SG 4812	SF 10386		SF 10395	Pump installed in tank. Not interchangeable with pumps of earlier Classes.
SSBN726 CL	AB 31K-200	SG 4824	SF 10524		SF 10394 & SF 10395	Pump installed in tank.

a. SSBN616 Class Pumps. The SSBN616 Class ships were the first to use the 31K-200 series pump. This unit is basically an enlarged version of other series of pumps that had been in existence prior to its development. The pump is mounted external to the vent and supply tank similar to the smaller pumps on earlier ships. The pump is equipped with a noise attenuation chamber (manifold) which effectively reduces fluid-borne noise generated by the pump. As SSBN616 Class ships began to receive their first major overhaul, screw pumps were introduced into the Advance Equipment Repair Program (AERP) to reduce overhaul time. A number of new pumps complete with motors were purchased and held in readiness to support overhauls. These pumps were the C prefix 31K-200 series discussed in subparagraph e.

b. SSN637 and SSBN640 Class Pumps. The screw pumps used in these classes are not interchangeable with earlier designs of 31K-200 pumps. These 31K-200 pumps are mounted in the vent and supply tank. Advantages of this are the reduction in piping through the manifolding of pump unloading and relief valves and filters on the tank top. In lieu of suction piping the pump inlet is well below the normal oil level and draws fluid directly from the tank. A relatively coarse mesh screen keeps large particles from entering the pump. The pump discharge goes directly out a port in the pump mounting plate to the various valves and filters. No interconnecting pipe is used for the components mounted on the vent and supply tank. The only major drawback to this installation is accessibility to the pump for repair; more time for removal and reinstallation is required.

c. 1K-200 Screw Pump. This pump is utilized in the SSN686 and 687 submarines. The pump is tank mounted complete with motor, coupling, noise attenuator, and screened inlet. The noise attenuator is of an improved design different from previous attenuators, but is interchangeable with the attenuators of the 31K-200 pumps used on SSN637 Class and the SSBN640 Class.

d. B31K-200 Screw Pump. This pump is used in the SSN688 Class submarine. The pump is tank-mounted complete with motor, coupling noise attenuator, and screened inlet. The noise attenuator is of a unique design and is not interchangeable with other designs. The pump case is different and not interchangeable with any other 31K-200 series pump.

e. C31K-200 Screw Pump. This pump is a replacement furnished under the AERP for SSBN616 Class ships. The pump is similar to the A31K-200 series except for:

   1 Inlet. The pumps are mounted external to the supply tank on SSBN616 Class; therefore, a different inlet is required.

   2 Outlet Opening. The outlet opening conforms to SSBN616 Class requirements and is different from the pumps furnished for SSN686 and SSN687.

   3 Bracket. A bracket is provided for shipping purposes only.

556-2.1.5.3 Maintenance of the 31K-200 Series Pumps. Screw pumps are very reliable and generally will last for many years assuming reasonable care has been provided; however, there have been several areas of recurring trouble in the 31K-200 series of screw pumps. The trouble areas discussed in a. through g. are not necessarily pump design deficiencies but may result from lack of maintenance information and guidance. The series 31K-200 pump is addressed specifically; however, the information is generally applicable to all the other DeLaval pumps used in submarine hydraulic systems.

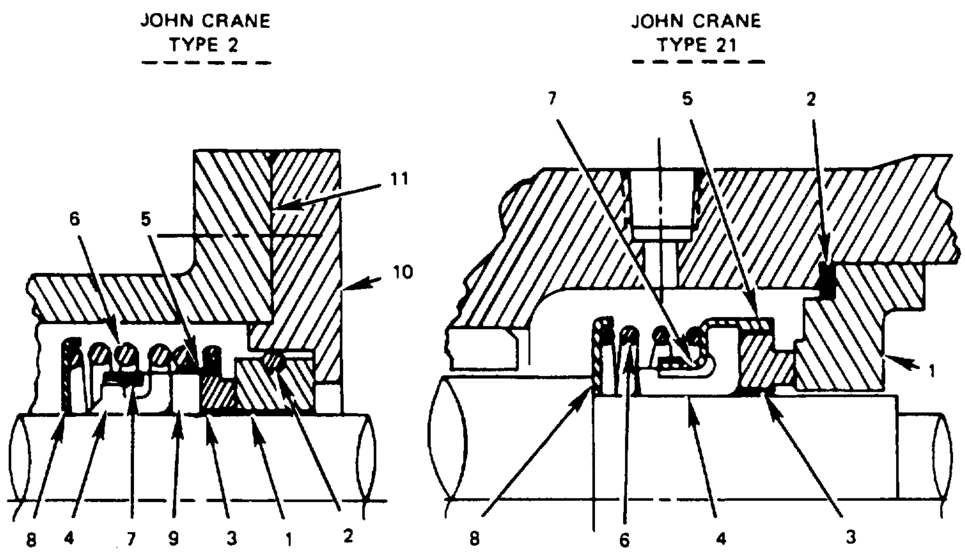
a. Rotor Housing Seal Leakage. Mechanical seal failure may be caused by improper O-ring groove dimensions in the rotor housing and balance piston housing. Insufficient squeeze on the installed O-ring allows high pressure oil to flow into the mechanical seal cavity faster than it can flow out of the leakoff passage back to the low pressure (inlet) end of the pump. The result of this condition is overpressurization with subsequent failure of the mechanical seal. Remedial measures that are proving effective include:

   1 Revision A of DeLaval detail drawings SG-4396 and SG-4437 required the O-ring groove diameter to be 4.480 in. to 4.469 in. which proved to be too deep. Revision B of the detail drawings increased the O-ring squeeze by calling for the groove diameter to be 4.521 in. to 4.525 in. In addition, backup rings are now provided to prevent seal extrusion and failure.

   2 During a pump overhaul, the rotor housing and balance piston housing O-ring grooves should be measured. In the event the grooves are found to be 4.480 in. to 4.469 in., the housings should be modified, or replacement housings to the latest revision of the detail drawings should be obtained. A new O-ring groove can be

cut into the housing; a suitable location is between the existing groove and the high pressure end of the housing. The balance piston housing cannot be as easily modified due to existing old passages. The existing grooves may be filled by brazing, but extra care must be used not to warp the piece. At completion of the modification, the entire balance piston housing must be checked to see that dimensions are still within drawing tolerances (refer to DeLaval drawings SG-4396 and SG-4402 for details of the parts discussed).

b. Mechanical Shaft Seal. During replacement of mechanical seals, the power rotor shaft in the area of the seal, the seal carbon element sealing surface, and the stationary element sealing surface should be inspected. Any pitting, scoring, or scratches are cause for rejection since they can result in leakage. Items found defective are not to be used; new components such as the rotor or mechanical seal, should be obtained from the supply system. The correct seal for the 31K-200 series pump is the John Crane Type 2 NSN 9C-4320-00-853-4071. This seal may be identified as John Crane Packing Company part number S-1375, Type 2, 1-3/8 in. bellows shaft seal with O-ring seat. The DeLaval part number is S-1446C/0200. Figure 556-2-7 depicts the John Crane, Type 2 seal and should be used for comparison with new seals.



PART NUMBER	PART NAME		PART NUMBER	PART NAME
1	SEAT		7	DRIVE BAND
2	SEAT RING		8	SPRING HOLDER
3	WASHER		9	DISC
4	BELLOWS		10	GLAND PLATE
5	RETAINER		11	GASKET
6	SPRING			

Figure 556-2-7. John Crane Types 2 and 21 Screw Pump Mechanical Shaft Seal with O-Ring Seal

c. Disassembly of the 31K-200 Screw Pump Mechanical Seal with the Pump in Place. When changing a mechanical seal with the pump case in place, it is necessary to remove the power rotor assembly from the pump case. Lift the power rotor slowly and smoothly while constantly rotating the power rotor in the counterclockwise direction so as to thread the idler rotors down into the pump case. Never lift the power rotor out of the case more than one inch at a time without hesitating momentarily to allow the idlers to thread back into the case. In doing this, if the idler rotors are lifted too high, they can separate from the idler balance pistons. When this happens and the pump is reassembled without the balance pistons in place, loss of hydraulic balance can result which will cause early pump failure. After the power rotor is removed, visually check to see that the idler balance pistons are not lying on the thrust block. Both idler rotors should extend out of the rotor housing the same amount (about 1/2 in.). If they are uneven by more than a 1/16 in., one of the idler balance pistons has probably fallen off the idler rotor, necessitating additional disassembly of the pump.

d. Mechanical Seal Installation. Inspect the power rotor surface in the area of the mechanical seal. No scratches or burrs are permitted. Thoroughly clean the seal area and lubricate with system fluid. Perform steps d.1 through d.4 (see Figure 556-2-7 for part numbers):

1 Install the spring holder (8) and spring (6).

CAUTION

Use extra care in handling the carbon washer as it can be cracked, chipped, or scratched easily. Any damage to the carbon washer is cause for its rejection.

2 Remove the carbon washer (3) from the remaining assembly.

3 Lubricate the bellows, retainer, drive band, and disc (4, 5, 7, and 9) with system fluid. Carefully install on the power rotor and seat against the spring.

4 Install the carbon washer; be sure the notches on its outer circumference line up with the corresponding detents inside the retainer (5). Install the seat into the seal housing before assembling it to the pump.

e. Screw Pumps Manifold (Attenuation Chamber) Configuration and Torque Requirements. The original manifolds as used in all of the SSN594 and SSN616 Class, and in several of the SSBN640 Class were welded fabrication without removable covers and no problems have been reported. The SSN637 Class, half of the SSBN640 Class, SSN671, and SSN685, had cast manifolds with removable covers which have been subject to bolt failures. These are the only manifolds covered in this paragraph and subparagraphs.

1 The original manifold covers, which were called out at part no. 79 on DeLaval drawing SG-4381 Revisions A through D inclusive, experienced many bolt failures. The failures have been attributed to cover flexing during cyclic operation of the pump with subsequent reduction in the bolt tension (due to loss of torque) and eventual bolt breakage. In Revision E, a modification was introduced which provides a reduced area of the cover, (106) exposed to pressure, plus a thicker cover (104), less susceptible to bending. The correct bolts and associated torque values for these two covers are provided on Revision F-2 of SG-4381.

2 Early design cast manifolds with removable covers may be modified to accept the stronger cover (104 of SG-4381), and internal changes shown on Revisions E and F. The new parts required for the modification may be obtained from the manufacturer. Modification of the earlier manifolds is to be considered an interim repair to be accomplished in the event DeLaval drawing SF-10402 manifolds are not available.

3 SF-10402 is a new manifold design developed as a replacement for the early and modified designs shown on SG-4381. This new manifold has resolved known problems. Eventually all cast SG-4381 manifolds are to be replaced with the SF-10402 design through implementation of ship alteration SSN1527 and SSBN1231 while SSBN616 Class ships are provided with the C31K-200 replacement pumps through the SUBMEPP AERP. Table 556-2-4 reflects the correct bolts and torque requirements for the various configuration manifolds that may be installed. Refer to Table 556-2-3 for a matrix of manifolds to pump and ship.

Table 556-2-4. BOLT AND TORQUE REQUIREMENTS

Mfg. Dwg No.	Bolt Part No.	Quantity Req'd	Description & Material	Use W/Cover Part No.	Required Torque
SG-4381	83	19	5/8″-11x2-1/2″ Long. FF-S-86 Ty VI & MIL-F-18240 Ty A insert	79	190 ±5 ft/lb

Table 556-2-4. BOLT AND TORQUE REQUIREMENTS - Continued

Mfg. Dwg No.	Bolt Part No.	Quantity Req'd	Description & Material	Use W/Cover Part No.	Required Torque
SG-4381	84	2	1″-8x3″ Long. FF-S-86 Ty VI & MIL-F-18240 Ty A insert	79	700 ±20 ft/lb
SG-4381	86	19	5/8″-11x2-7/8″ Long. AMS 6487 & MIL-F-18240 Ty A insert	104	130 ±5 ft/lb
SG-4381	87	2	1″-8x3-1/4″ Long. AMS 6487 & MIL-F-18240 Ty A insert	104	380 ±10 ft/lb
SF-10402	88	16	3/4″-10x3-1/4″ Long. FF-S-86 Ty VI & MIL-F-18240 Ty A or B insert	82	250 ±30 ft/lb -00
(SF-10402 is the applicable detail drawing for assembly drawings SF-10332 & 1042)					

f. Power Rotor Ball Bearing. The 31K-200 series screw pump, as received from the manufacturer, has power rotor ball bearings identified by DeLaval part number 307S-ABEC-5. This part is common to all the 31K-200 series pumps. When installing a new power rotor in a 31K-200 series pump, a new ball bearing should be used. The NSN of the bearing is 1H-3110-00-987-3723. The bearings are of the noise tested type and are selected to maintain the quiet operation of the pump. Preferred and alternate methods of bearing installation are discussed in f.1 and f.2. Part numbers in the installation procedures refer to DeLaval Drawing SG-4381.

1 Ball Bearing Installation - Preferred Method. The preferred method of installing a new bearing is to heat the bearings in a convection oven at 80° to 90°C for one-half hour.

NOTE

See NSTM Chapter 244, Propulsion Bearings and Seals, for convection oven and bore heater procedures for expansion of bearing rings.

After heating install bearing on shaft. Ensure that bearing is firmly seated against the balance piston (39). Be sure that spacer and snap ring (35 and 36) can be fitted after the ball bearing is seated against the balance piston.

2 Ball Bearing Installation - Alternate Method. If no ovens are available, pressing the bearing onto the shaft is permissible. However, care must be used during installation of new bearing to avoid galling the power rotor shaft. The inner race must be the only part of the bearing assembly used for pressing the bearing into place. Before assembly of the bearing onto the shaft be sure that spacer (35) for the 31K-200 pump is installed in correct relationship to the bearings. Review the applicable assembly drawing in order to determine whether the spacer goes on before or after the bearing. Premature failure can be expected if the assembly order is reversed. Check radial movement between bearing races by hand; there should be no perceptible play (clearance) between inner and outer races.

g. Alignment of 31K-200 Screw Pump Balance Piston Housing. The balance piston bushing can be installed misaligned to the pump case discharge port. The probability of misalignment can be reduced by performing the procedures in g.1 through g.6.

1 Align the rotor housing properly in the pump case and install the housing stop pin.

2 Insert special pin in rotor housing hole.

3 Bolt the seal housing to the balance piston housing. Be sure the dowel pin is installed between the two housings.

4 Insert the housing without O-rings into the pump case. Carefully align special pin with hole in balance piston housing (this is a blind fit) and bottom the balance piston housing out on the rotor housing. Verify that special pin is in the balance piston housing hole by attempting to rotate the seal housing using a strap

wrench. When properly installed and aligned, the seal housing cannot be rotated in either direction. When proper installation is ensured, accurately match mark seal housing and the pump case for future reference.

5 Remove balance piston housing and seal housing. Separate them.

6 Install necessary seals and reassemble pump taking care to align match marks between the seal housing and pump case.

556-2.1.5.4 Standardized 31K-137 and 31K-156 Screw Pumps. The 31K-137 and 31K-156 series of screw pumps were installed in ships having numbers from the early SS500's through the SSBN616 Class. Over the years many design changes have been incorporated which generated a number of similar but not necessarily interchangeable parts. The multitude of similar parts required to support the evolution of these pumps has resulted in a logistic support problem. The internal parts available for the later issue of pump can be backfitted to the earlier pumps. In order to promote economy while updating order pumps, several lists of material were developed to incorporate acceptable existing components. In addition to these lists of material, several SHIPALTS were required to cover the different ship types such as SS, SSN, and SSBN that used these pumps. The ship alterations are intended for incorporation as soon as possible, and are not limited to accomplishment only when a pump repair action is required. The ship alteration kits are not a source for repair parts. If ship alteration kit parts are used for repair purposes without accomplishing the ship alteration, all parts are not used, thereby generating another form of non-standard pump. Each ship alteration calls for a software package which contains instructions for disassembly and disposition of existing pumps and parts, reassembly instructions per the new assembly drawings, a complete set of applicable outline drawings, and a list of material covering new material. Refer to Table 556-2-5 for a matrix of ship alterations to ships.

Table 556-2-5. SCREW PUMP STANDARDIZATION PROGRAM

Ship Alteration	Pump Series	Pump Applicability
SS1074	31K-137	SS572, 573, 576 & 577 ships
SS1131	31K-137	SS563, 565 & 574 ships*
SS1129	31K-156	SS572, 573, 580, 581, 582 ships
SS1132	31K-156	SS563, 565, 567 & 574 ships*
SSN897	31K-137	SSN585 CI, SSN587 ships & SSN594 CL (less 594, 103, 104, & 612 ships)
SSN1228	31K-156	SSN597, 587 & 612 ships
SSBN898	31K-156	SSBN608 CI
SSBN651	31K-137	SSBN598 CI, SSBN608 CI, SSBN616 CI

* This ship alteration provides for replacement of complete pump in lieu of internal parts because the original pump cases were fabrications susceptible to leakage at the welded seams.

a. APL. The standardized pumps will use the Allowance Parts Lists (APL) for post-standardization repair action shown in Table 556-2-6.

Table 556-2-6. POST-STANDARDIZATION REPAIR APL

APL	Pump Series
016160757	31K-137
016160977	31K-156

b. Mechanical Seal. Both the 31K-137 and 31K-156 pumps utilize the John Crane Type 21 mechanical seal. This seal replaces, with no modification, the earlier John Crane Type 9 seal. This replacement seal is available under NSN 9C-4320-00-221-4610. Figure 556-2-7 shows a John Crane Type 21 seal and should be used for comparison with new seals to be sure the correct one is in hand. During seal replacement, a thorough inspection of the power rotor shaft in the seal area must be made to be sure no pitting, scoring, or scratches exist; the presence of any such defect is cause for rejection. Guidelines provided for replacement of the seal (refer to Figure 556-2-7 for part numbers) are:

1 Install the spring holder (8) and spring (6).

CAUTION

Use extra care in handling the carbon washer as it can be cracked, chipped, or scratched very easily. Any damage to the carbon washer is cause for rejection.

2 Remove the carbon washer (3) from the remaining assembly.

3 Lubricate the bellows, retainer, and drive band (4, 5, and 7) with system fluid. Carefully install on the power rotor and seat against the spring.

4 Install the carbon washer (3), being sure the notches on its outer circumference line up with the corresponding detents inside the retainer (5).

5 Carefully slide the seat (1) on the power rotor and against the carbon washer.

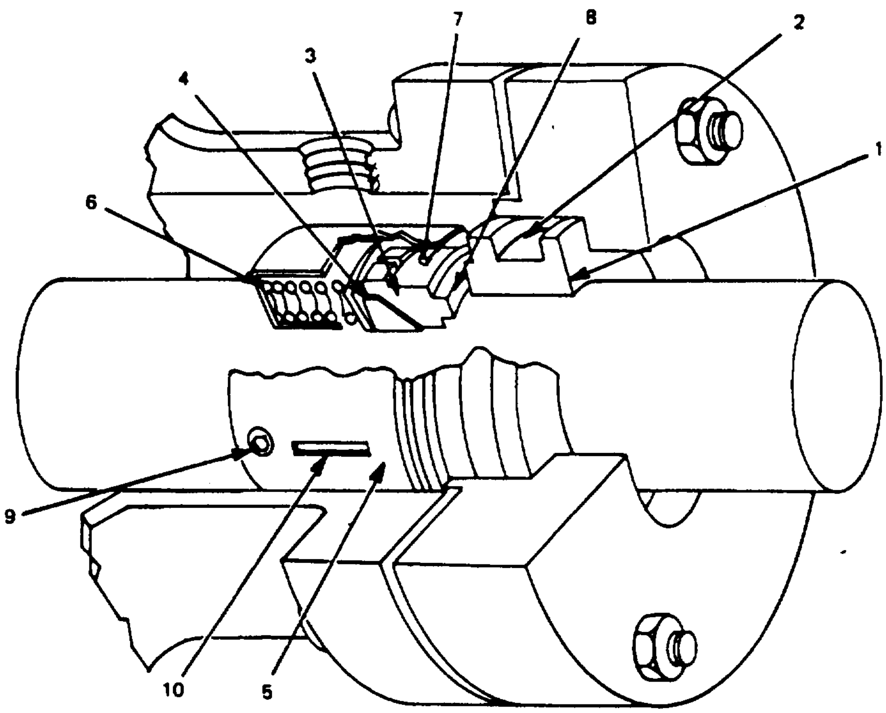
556-2.1.5.5 6DBX-156 Series Screw Pump. This series screw pump is used in the SSN637 Class, SSBN640 Class, SSN671, and SSN685 ships for the external hydraulic system. The only reported problem with this pump involves failure of the rotor housing retaining snap rings. One snap ring is installed in the pump case bore at each end of the rotor housing. As the pump goes through a cycle from zero to full operating pressure and back, the snap ring is flexed in its groove and eventually failure of the ring occurs. The inboard snap ring can be deleted by installation of a new inboard flange as indicated in TRS 0553-086-010. SHIPALT SSN1836 authorizes deletion of the outboard ship ring by the installation of a split ring. Pumps delivered to the SSBN640 Class ships at construction were manufactured without snap rings; therefore no modifications are required for these pumps.

a. Mechanical Shaft Seal. The 6DBX-156 pump uses the John Crane Type 9 seal identified by Crane drawing CG-SP-14801 and obtainable through NSN 9C-4320-00-018-0466.

b. Seal Replacement. During replacement of mechanical seals inspect the power rotor shaft in the area of the seal, the seal carbon element sealing surfaces, and the stationary seat sealing surface. Any pitting, scoring, or scratches are cause for rejection since they can result in leakage. Items found defective are not to be used; new components (rotor or seal) are to be obtained from the supply system.

c. Seal Disassembly. Refer to paragraph 556-2.1.5.3 for general guidance in disassembly of this seal.

d. Installation. Inspect the power rotor surface in the area of the seal; no scratches or burrs are permitted. Thoroughly clean the seal area and lubricate with system fluid. Refer to Figure 556-2-8 for part numbers discussed in procedures d.1 through d.4:



1 - STATIONARY SEAT	6 - MULTIPLE SPRING
2 - SEAL RING	7 - RETAINING SNAP RING
3 - SEALING WASHER	8 - SEALING FACES
4 - TEFLON WEDGE	9 - SEAL SET SCREWS
5 - SEAL RETAINER	10 - DRIVING NOTCH

Figure 556-2-8. Mechanical Shaft Seal for Screw 6DBX-156 Series Pump

1 Lubricate the seal assembly with system fluid.

2 Slide complete assembly (3, 4, 5, 6, 7, 8, 9, and 10) onto shaft.

NOTE

Be sure that ball bearing spacer and snap ring (27, 28, and 29 on SG-4341) have been installed before seal installation.

3 Seal the base of part 5 firmly against the snap ring (29) and tighten set screws (9). Stake the set screws to prevent their backing out.

4 Assemble parts 1 and 2 and install into the seal housing (17) of SG-4341.

556-2.1.5.6 31K-187 Series Screw Pump. This series screw pump is used only in the SSN594 Class ships (less the SSN594 ship) for the main and vital pumps. This series of pumps and those 31K-156 pumps used for the SSN594 Class were originally designed with snap rings to position and retain the rotor housing. These pumps were subject to the same failures as the 6DBX-156 discussed above. Elimination of the snap ring is authorized by ship alteration SSN659. The outboard end of the pump case is machined to eliminate the snap ring groove and provide an increased area for a spacer ring. The inboard snap ring groove is machined out to provide an area for a new inboard end cover. Comparison of DeLaval drawings SG-4041 revisions C and D for the 31K-187 pump and SG-4054 revisions C and D, for the 31K-156 clearly show the modification. The mechanical shaft seal used in the 31K-187 pump is the same as that used in the 31K-200 series, therefore the same replacement procedures apply (refer to paragraph 556-2.1.5.3).

556-2.1.5.7 General Guidance for Installation of Ball Bearing. The following subparagraphs provide general guidance for ball bearing installation in series 31K-137, 31K-156, 6DBX-156, and 31K-187 screw pumps. Refer to DeLaval assembly drawings for applicable part numbers as follows: 31K-137 - SG-4701; 31K-156 - SF-10068; 6DBX-156 - SG-4341; and 31K-187 - SF-4041.

a. Preferred Method. The preferred method of installing a new bearing is to heat the bearing in a convection oven at 80°C (176°F) to 90°C (194°F) for half an hour.

NOTE

An induction heater may be used if heating time in relation to bearing size has been determined. Induction heater voltage must be reduced to zero before removing bearing from heater.

1 Remove bearing from oven (heater) and install on shaft.

2 Ensure that bearing is firmly seated against either the power rotor shaft shoulder or spacer (39) or balance piston (refer to applicable assembly drawings).

b. Alternate Method. If no ovens are available, pressing the bearing onto the shaft is permissible. During installation of a new bearing, care must be used in order to avoid galling the power rotor shaft. The inner race must be the only part of the bearing assembly used for pressing the bearing into place. Before assembly of the bearing onto the shaft, be sure the spacer (39) for 31K-137 and 31K-156 pumps is installed in correct relationship to the bearings. Review the applicable assembly drawing in order to determine whether the spacer goes on before or after the bearing. Premature failure can be expected if the assembly order is reversed. Check radial movement between bearing races by hand; there should be no noticeable clearance (play) between inner and outer races.

556-2.2 HYDRAULIC MOTORS

556-2.2.1 GENERAL. Hydraulic motors are basically the same as hydraulic pumps except that they are used to convert hydraulic energy back to mechanical (rotary) energy. Nearly all hydraulic motors in Navy application are either vane type or piston type. The lower efficiency of a gear or screw type motor would be unacceptable, therefore these types are seldom used. The most commonly used hydraulic motor is the fixed displacement piston type. A few equipments use a variable displacement piston motor where very wide speed ranges are desired. Vane type motors are generally restricted to application where the horsepower transmitted is relatively low and where starting loads are not particularly high compared to the running load.

a. One type of hydraulic motor that is being used in an increasing number of applications is the low-speed large-displacement radial-piston motor illustrated in Figure 556-2-9. This unit is somewhat similar to the radial pump, only it is specifically designed for low speeds and will develop high torque. Because of these features, these motors frequently make it possible to drive loads directly without the need for gear boxes or speed reducers.

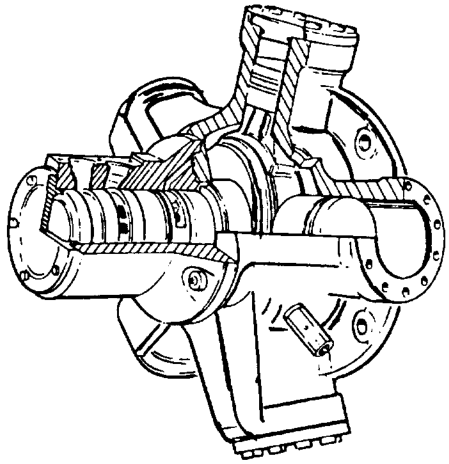


Figure 556-2-9. Hydraulic Motor

b. The design of hydraulic motors is basically similar to the corresponding type of pump. The vanes in a vane type unit may be mounted differently in the rotor and the pipe connections may be the same for inlet and outlet rather than of different size as is frequently found on pumps. Piston motors will generally have valve plates which are different from the valve plates used in pumps. These differences are due to the fact that the motors nearly always must turn in either direction with equal efficiency whereas a pump is designed to operate most efficiently for one direction of rotation. When overhauling hydraulic motors, do not assume that similar parts from a pump may be used without verifying that part is interchangeable.

556-2.3 HYDRAULIC ACTUATORS

556-2.3.1 GENERAL. In addition to hydraulic motors, there are various types of actuators for converting the hydraulic energy developed by a pump back into mechanical energy. The more commonly used actuators are cylinders, ram units, and rotary actuators. All actuators use seals for closing the small clearances between the moving and stationary metal parts. These seals may be O-rings, formed lip seals, chevron packings, or other type packing of various composition. All seals and packings will be damaged by contaminated fluids. Damaged seals result in lower operating efficiency and leakage. When installing seals, care must be observed that the seal is not damaged or cut. All newly installed seals should be wetted with clean operating fluid before installing into the bore or reinstalling the packing gland. Operating an actuator with completely dry seals may ruin the seal. Most actuators are self lubricating once the system is operating. Air in an actuator will cause springy erratic operation. Before using the actuator to move a load, it is important that it and the pipes leading to it be purged of air.

556-2.3.2 CYLINDERS. Hydraulic cylinders are used where linear motion may be employed to move some mechanism.

a. Basically an actuating cylinder consists of a tubular housing (the cylinder), end caps, fluid ports, a piston, piston rod, and a packing gland or seal. Cylinders are usually double acting, which means that the fluid under pressure can be applied to either side of the piston so as to provide a force in either direction. Cylinders are generally not designed to absorb any significant side force.

b. Most hydraulic cylinders use O-rings or quad-rings for seals between the piston and cylinder bore and frequently at the gland where the rod comes through the end cap. To prevent damage to the O-ring or rolling of the ring, the surface of the cylinder bore or piston rod along which the O-ring rubs must be a very fine finish and must be free of scores, nicks, corrosion, or any other imperfections. If O-rings must be replaced and there are no specific part numbers or identification of the seals available from instruction manuals, use the guidance provided in Section 11 of this manual for selection of a replacement. A properly installed seal or packing at the piston rod opening in the end cap will leave a light film of fluid on the rod as it emerges. This film of fluid lubricates the seal as the rod retracts into the cylinder and helps to flush away minor contamination that has collected on the rod. Every effort should be made, however, to protect the piston rod from being contaminated or damaged. If the unit has not been operated for a long period and the exposed part of the piston rod is dry, dirty, or corroded, the rod should be cleaned carefully and coated with clean hydraulic fluid of the type used in the system before operating the unit. Burrs or scratches on the piston rod should be removed with a fine whetstone.

556-2.3.3 RAMS. Hydraulic rams, like hydraulic cylinder assemblies, are used to apply a linear force or motion to a mechanism. Rams are generally used where very large forces are needed or where there is a considerable side force which must be absorbed in the actuator.

a. An example of such an installation is a surface ship steering gear ram where the linear motion of the actuator must be converted to rotary motion at the rudder tiller. At the extreme positions of the tiller, the linkages exert a large side force on the ram.

b. Basically the ram consists of a cylinder with one end open and the other end closed. A plunger assembly, with an outside diameter only slightly smaller than the inside diameter of the cylinder, fits into the open end. Near the open end, a bushing is fitted to the bore of the cylinder. The bushing keeps the plunger aligned in the cylinder and absorbs side forces applied to the plunger. Further toward the opening in the cylinder, a packing or seal assembly is provided to close the space between the plunger and cylinder bore. Fluid enters and leaves the cylinder through a port generally located near the closed end of the cylinder.

c. A basic ram assembly is single-acting and exerts a force in only one direction. When used as a single unit, the attached load or a spring must provide the necessary force to retract the plunger when the hydraulic fluid pressure is released. In other applications, such as a steering gear actuator, the ram assembly has two opposing cylinders with the plunger moving back and forth between the two cylinders. The plunger then has a crosshead at the midpoint where linkages are attached to convey the force generated by the ram to the connected mechanism.

d. Ram packings should be kept sufficiently tight to prevent observable leakage but loose enough to allow a light film of fluid to remain on the plunger as it emerges from the cylinder. The plunger should be kept clean, smooth, and lightly coated with fluid at all times. If burrs or scratches on the plunger are noticed, they should be smoothed out with a fine whetstone as soon as possible. If plungers are severely scored, corroded, or damaged, the plunger should be removed and refinished. If considerable material is removed from the plunger in order to obtain a good finish, the cylinder bushings and packings must be replaced to accommodate the smaller plunger.

556-2.3.4 RACK AND PINION PISTON TYPE ROTARY ACTUATORS. Rack and pinion type actuators of the single or multiple, bi-directional piston type are used for turning, positioning, steering, opening and closing, swinging, or any other mechanical function involving restricted rotation of interfering mechanical devices. A typical rack and pinion double piston actuator is shown in Figure 556-2-10.

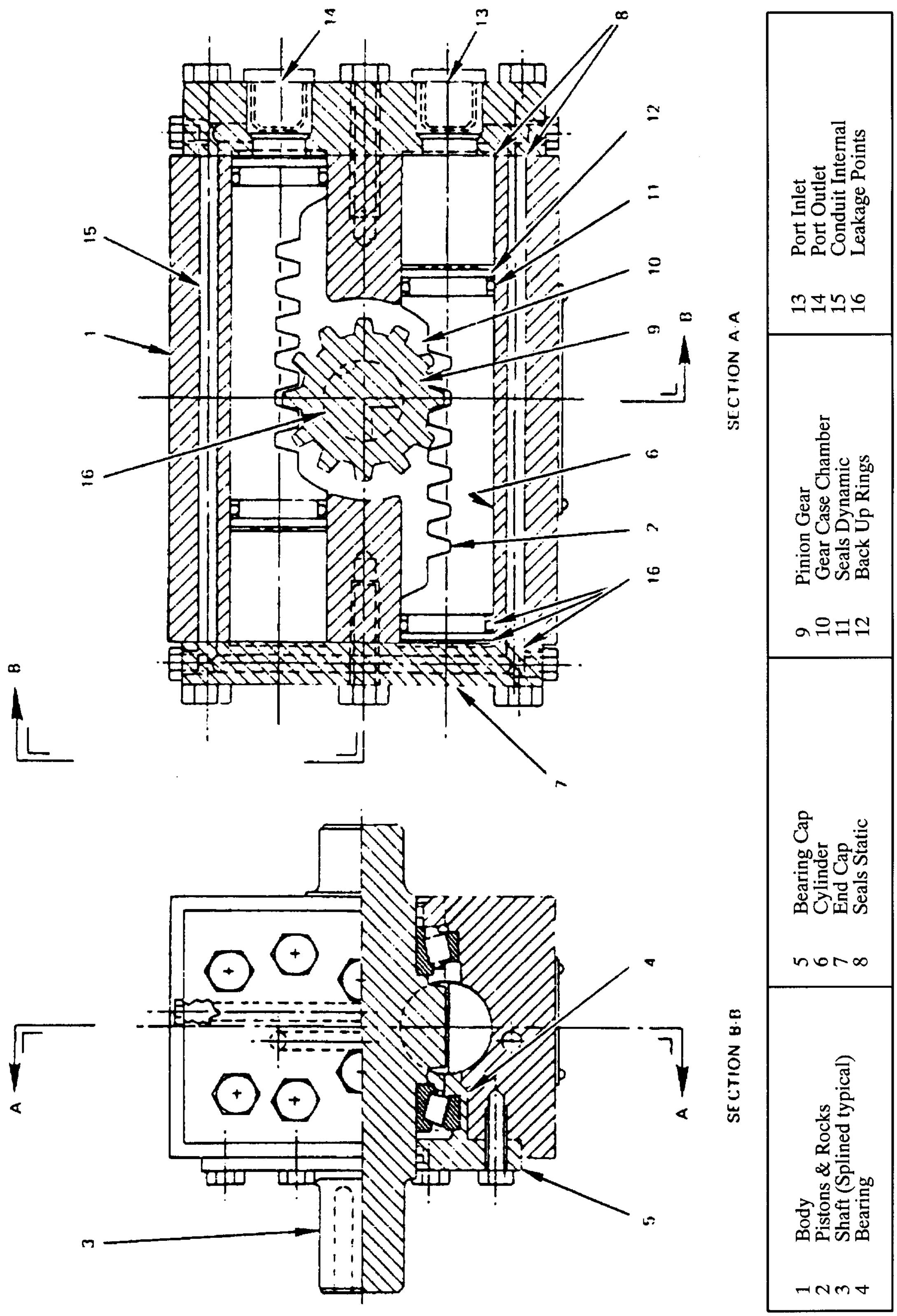


Figure 556-2-10. Double Rack and Pinion Type Rotary Actuator

556-2.3.4.1 Design and Operation. Basically the actuator consists of a ductile iron, aluminum, or nickel-aluminum bronze body (1), and double reciprocating pistons with integral rack (2), for rotating a shaft (3) mounted in roller or journal bearings (4). The shaft and bearings are located in a central position and are enclosed with a bearing cap (5). The pistons, one on each side of the rack, are enclosed in cylinders (6) machined or sleeved into the body. The body is enclosed with end caps (7) and static seals (8) to prevent external leakage of pressurized fluid.

a. The piston rack meshes with, and drives a pinion gear (9) enclosed in a gear case chamber (10) initially filled three-quarters full with the system's hydraulic operating fluid. The fluid provides a lubricant bath for the pinion gear.

b. The pistons are usually provided with O-ring seals (11) and backup rings (12), or special packings not requiring backup rings. These seals prevent fluid from leaking back into the gear case chamber and provide wiping of the cylinders in which they reciprocate.

c. The actuator is provided with fluid ports (13) and (14) serving alternately as inlet and exhaust ports, and an internal passage (15) for supplying and exhausting fluid to and from opposite ends of the cylinders.

d. Prior to an operation, both ends of each cylinder are filled with the system fluid. During the operation, fluid under pressure is applied to the pistons through port (13), moving the pistons in a linear motion and exhausting the fluid at the opposite end port (14). The linear motion of the piston rotates the pinion gear and shaft (3) providing output torque and shaft angular rotation to operate valves or other mechanical devices.

556-2.3.4.2 General Causes of Actuator Fluid Leakage. Internal fluid leakage is fluid that leaks past the seals (11) back into the gear case chamber while the actuator is in a pressurized static or operational mode. This leakage eventually will fill all internal cavities including the gear case chamber. The fluid will then be forced out by the operating pressure and become external leakage which can be observed around the main gear case pinion shaft. External fluid leakage is fluid leaking past dynamic or static seals, to the outside of the actuator that can be observed visually, such as intermittent drips or a continuous flow. Fluid dampness or smears on fingers or hand when rubbing the hand around connections are not considered excessive leakage. See Figure 556-2-10 for location of leakage points. The general causes of fluid leakage are:

a. Seal failure, caused by mechanical imperfections at the seal glands, at the pistons or on cylinder walls.

b. Grooving and scoring of the cylinder or sleeve bores, by cuttings created by contact of the pinion gear with the sleeve which is not in proper position.

c. Defective seals.

d. Seal deterioration due to incompatibility with hydraulic fluid.

e. Seal deterioration due to mechanical wear or aging.

556-2.3.4.3 Sargent Rotary Actuator Leakage. Hydraulic rotary actuators (rack and pinion type) manufactured by Sargent Controls, of the general design shown in Figure 556-2-11 have frequently developed external leakage problems after being overhauled or repaired. This leakage appears as flow from the actuator relief valve whose function is to relieve pressure buildup in the pinion cavity. Inspection and analysis has shown that the leakage is usually caused by scratched and scored actuator sleeve sealing surfaces upon which the piston (rack) dynamic seals slide and seal. The scoring is caused by the pressure of wear particles that have been chipped away from the sleeve due to metal-to-metal contact of the sleeve with the pinion gear. Due to the design and configuration of the rotary actuator, it is possible to reassemble the unit such that careless torquing of the endcap bolts causes the actuator sleeve to be displaced off the centered position with respect to the pinion and body. This displacement can cause the sleeve to contact the pinion, thus providing a metal-to-metal wear surface. During actuator operation (that is, pinion rotation), the pinion can cut away metal particles from the sleeve. These particles can become lodged under the racks and other places internal to the actuator, resulting in scored sleeves and torn or damaged seals. The eventual loss of the seal or sealing surface provides a leak path that allows oil to enter the pinion cavity and escape through the relief valve.

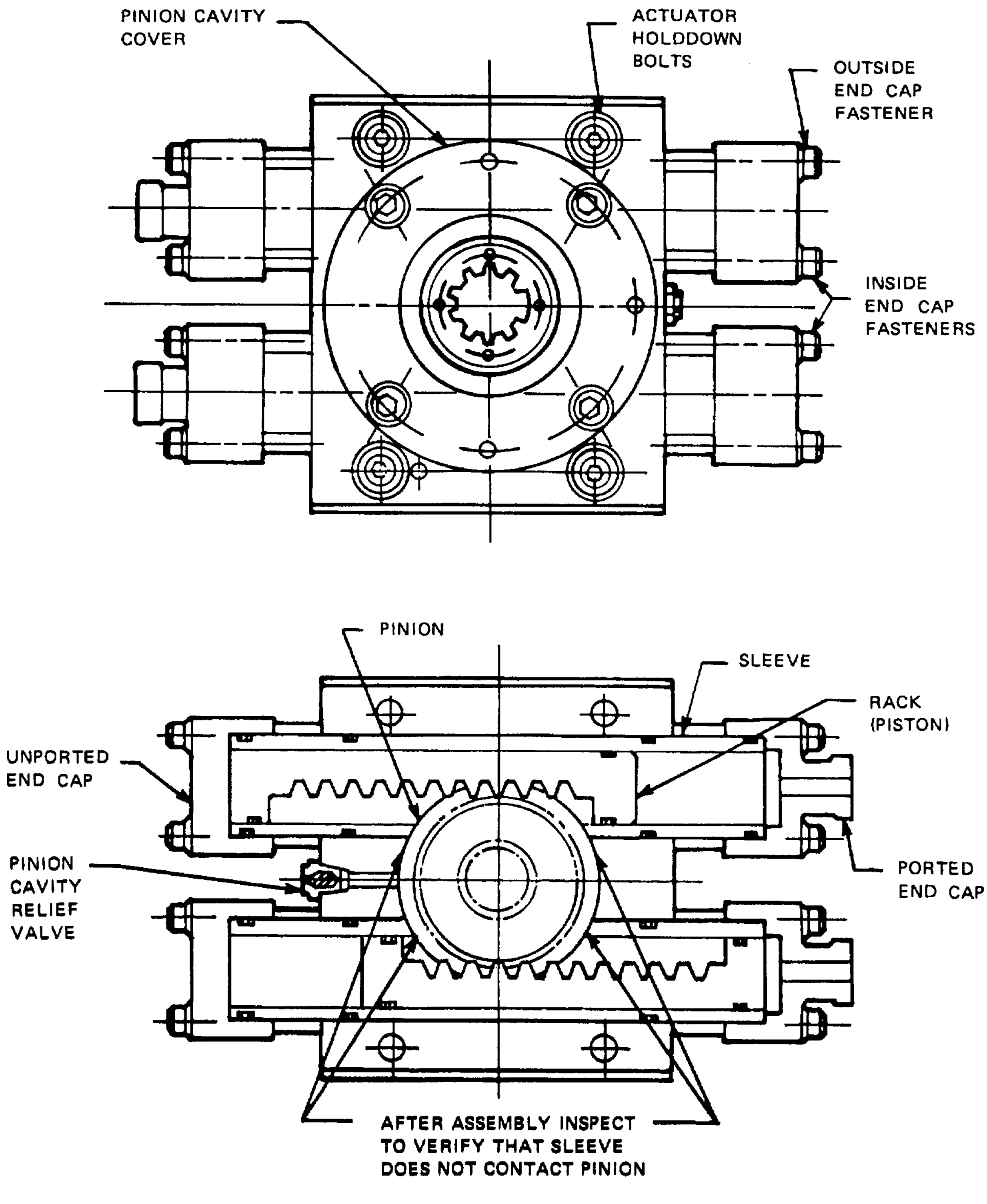


Figure 556-2-11. Sargent Rotary Actuator

556-2.3.4.4 Replacement Seals to Minimize Leakage. One of the major problems associated with piston type rotary actuators has been external leakage. Several improved type seals have been tested and authorized for use in rotary actuators which tend to minimize leakage problems. In Table 556-2-7 is a listing of the type of seals which may be used in static and dynamic applications. These seals are improved alternates to the O-rings usually employed in the original designs. Action is being taken to revise technical documentation to show the improved seals. If the logistic support documentation has not been revised the improved seals can be used as temporary replacements. For permanent installation a request should be submitted to Naval Sea Systems Command (NAVSEA) so that the change can be considered on a class-wide basis and supporting documentation can be revised as necessary to ensure logistic support. The request to NAVSEA should include identification of the equipment, APL number, identification of existing seals, and the proposed replacement seals. The various replacement seals are described briefly below.

Table 556-2-7. PACKING AND SEAL REPLACEMENTS FOR RACK AND PINION TYPE ACTUATORS

Seal Type	Static and Dynamic Seal Replacements for O-ringSeals in MIL-G-5514 Glands	
	Static Glands for 0, 1 or 2 backup rings	**Dynamic Glands for 2 backup rings**
Standard - ESCL (Without Backup Rings)	Acceptable	Do not use
Deep Type B - ESCL (Without Backup Rings)	Do not use	Preferred
T-Ring	Do not use	Good
O-Ring per MIL-R-83248, and 83248/13	Preferred	Acceptable
NOTE 1 Seal selection preferably shall be made in accordance with indicated ratings. ESCL seals will fit glands identified to O-ring dash sized -210 through -460; T seals will fit glands to O-ring dash sizes -110 through -116, and -210 through -460.		
NOTE 2 Generally recommended for use only when gland condition is such that an O-ring does not provide a good seal. Do not use as a face or boss seal.		
NOTE 3 Backup rings, in accordance with MS 27595 and M8791/1 (either type), are authorized for use with O-ring seals specified in MIL-R-83248/1.		

a. Elastomeric Spring Loaded Compression Lip Seals (ESCL). These seals combine a polyurethane base polymer U-lip type seal (90 to 95 durometer hardness) with a spring-loading mechanism (synthetic rubber O-ring or four-lobed rubber spring resembling a quadring) fitted into the recess of the U to maintain sealing pressure of the U. These packings are self-lubricating, seal in a single direction only, do not require anti-extrusion devices (back-up rings), and are suitable for use only with petroleum base fluids. These seals are described in detail in NSTM Chapter 078, Seals. These seals are directly interchangeable with most O-ring seals (see NSTM Chapter 078 for guidance) and provide adequate sealing in O-ring glands having up to 0.010 of an inch less squeeze than the minimum provided in MIL-G-5514 glands. The packings must be installed with the spring loading mechanism (O-ring) facing the pressure side. The two styles of ESCL packing recommended for use in actuators can be recognized by their cross-sectional shape. The standard type packings have a square cross section while the Deep Type B seals have chamfered lips and a rectangular cross section.

b. T-Rings. The T-ring is a unique packing that combines a resilient rubber sealing ring with a cross section like an inverted T, and precisely dimensioned special mating, non-extrusion (backup) rings, one on each side of the sealing elements. T-rings are used in single or double acting (bi-directional) seal applications, but are specified here for use in petroleum base hydraulic fluids only. T-rings are made to interchange with all standard O-ring sizes and will fit all corresponding MIL-G-5514 O-ring glands sized for two backup rings. T-rings specifically recommended for actuators are described in detail in Section 6 of NSTM Chapter 078 along with part numbering systems. For seal size identification, refer to the applicable APL, actuator drawings, or technical manuals. Applicable APL's are being revised to provide proper T-seal identification and spare parts provisioning. The T-ring packings are designed to provide an adequate sealing capability in O-ring glands having as much as 0.010 of an inch less squeeze than that provided by MIL-G-5514 glands.

c. O-Ring Seals. O-ring seals shall be in accordance with MIL-R-83248 and are applicable for use in single or double-acting systems (bi-directional), for petroleum and synthetic base fluids. Except for boss seals, O-ring gland dimension shall be as specified in MIL-G-5514 OR SAE AS4716. For boss seal applications, the MIL-R-83248/2 O-rings shall be used. O-ring seals shall be used in static sealing conditions without backup rings, unless backup rings are otherwise specified on drawings. Two backup rings, one installed on each side of the O-ring seal, shall be used for all dynamic seal conditions. O-ring seal shall be as recommended in Table 556-2-7, except that the replacement of an existing T-seal or ESCL seal with an O-ring should be avoided. However, the opposite action, replacing O-rings with T- or ESCL-seals in dynamic actuator applications will generally improve performance, particularly when sealing surfaces are worn or have been repaired, providing less squeeze than required by MIL-G-5514. National stock numbers are listed in the Navy Master Cross Reference List for the appropriate O-ring size under part numbers M83248/1-XXX and M83248/2-XXX. Backup rings shall be in accordance with MIL-R-8791 and MS27595, MS28773, or M8791/1. (See Section 3 of NSTM Chapter 078 for guidance.)

556-2.3.4.5 Hydrostatic and Leakage Testing. As a minimum, it is necessary to conduct hydrostatic and leakage tests of actuators which have been repaired. These tests can also be conducted prior to repair to help identify parts requiring repair or replacement.

a. Hydrostatic Testing. Prior to hydrostatic testing, all external bolts and nuts shall be torqued in accordance with actuator drawing requirements. If no torque requirements are identified on drawings see torquing requirements for reassembly in paragraph 556-2.3.4.7. To conduct the leakage test:
   1 Position the pistons at one extreme of the actuator as shown in Figure 556-2-10.
   2 Fill the actuator with fluid.
   3 Plug the port on the side of the piston containing the largest volume of oil (Port 13 in Figure 556-2-10).
   4 Connect the hydraulic supply to the port which will tend to move the piston (Port 14 in Figure 556-2-10).
   5 Vent trapped air from piston cavity.
   6 Through the hydraulic supply connection, pressurize the actuator to one and one-half times the operating pressure in the system in which the actuator is to be installed. Maintain the pressure for five minutes.
   7 During, and at the completion of the test, conduct an external inspection of the actuator. There shall be no visible evidence of damage, broken or cracked parts, loosening of bolts or nuts, or stripped threads.
   8 Inspect actuator for external leakage. No drips or continuous flow of fluid is acceptable. A slight dampness or oil film which smears the fingers is generally not considered a cause for rejection.

b. Leakage Testing. The leakage test can be accomplished simultaneously with the hydrostatic test set-up using additional procedures:
   1 Ensure that the actuator gear case is completely filled with fluid. For actuators with relief ports, the gear case chamber may be filled by removing the relief port plug. For other actuators the bearing cap must be removed in order to fill the gear case.
   2 For actuators with relief ports, leave the port open and attach a line to the relief port with the use of an adaptor. Fill line with fluid so that leakage can be easily identified. Plastic tubing is ideal as a rise in fluid level is immediately visible.
   3 If leakage is observed from the relief port line or at the main pinion shaft or end cap sealing, it is not satisfactory and must be corrected before the actuator may be installed.

556-2.3.4.6 Inspection of Internal Parts. When repairing or overhauling actuators, disassemble the actuators and perform an internal visual and mechanical inspection of all component parts to determine their acceptability.

a. O-ring grooves, housing, cylinder bores, piston heads, rack teeth, pinions, shafts, bearings, end closures, and other mating or moving parts which are in contact with each other shall be checked for burrs and minor nicks in O-ring grooves, corrosion, rust, hairline cracks, and pitting. Corrosion and rust shall be removed and the affected surfaces shall be restored to a surface finish and gland dimensions not to exceed the values specified in paragraph 556-2.3.4.7.

b. Measure cylinder bores and piston heads in at least three locations for out-of-round conditions. Cylinder bores and piston heads shall not exceed 0.015 of an inch (0.381mm) out-of-round in any location.

c. Examine the piston rack, pinion gear, and splined pinion shaft for worn, damaged, or chipped teeth. Also examine the pinion shaft for damage, out-of-round, chipped, or damaged keyway and key. Examine the journal bearings and bushings, as applicable, for chips, out-of-round, and warpage. Roller and ball bearings shall be inspected in accordance with NSTM Chapter 244, Propulsion Bearings and Seals .

556-2.3.4.7 Repair and Reconditioning of Actuators. Actuators and parts shall be reconditioned in accordance with the following procedures:

a. Cleaning. Thoroughly clean all internal and external parts and surfaces with clean, lint free, solvent dampened, cloths and wipe dry. Solvent shall be in accordance with MIL-C-81302 type II. Do not allow solvent to contact seals.

b. Reconditioning. Remove burrs from internal surfaces, sharp edges, and as much rust, corrosion pitting, nicks, and scratches as possible with a fine crocus cloth, soft cleaning compounds, honing, soft wire brush, or by light machining. Hairline scratches shall not exceed six inches (150mm) in length. Where plating buildup is used to restore surfaces to the required dimensions, fill the surface irregularities with copper and apply to the surfaces nickel or cobalt nickel plating in accordance with the requirements specified in NAVSEA 0900-LP-038-6010, Deposition of Metals by Contact (Brush on Method) Electroplating. Internal surfaces and dimensions of sealing areas shall be restored as described in subparagraphs 1. and 2.

   1 Surface Finish. Finishing to obtain the specified finish shall be performed by cleaning, honing, or light machining. Internal surface finishes for O-ring grooves, face seals, cylinder bores, piston heads, shafts, bearings, mating moving parts that are in contact with each other, and surfaces over which seals must slide or rotate shall meet applicable drawing requirements. Surface roughness for areas not identified are not critical; however, sharp burrs or edges should be removed, and surface finishes should not exceed 125 micro-inches. Surface finishes for packing glands shall meet the requirements of MIL-G-5514. When surface finish requirements are not available on TRS drawings, the surface finish shall meet the requirements listed in Table 556-2-8.

Table 556-2-8. SURFACE ROUGHNESS HEIGHT RATING

Part of Unit	Maximum Height
Cylinder bore (diameter over which packing must slide)	16
Rack and pinion teeth, shafts, backings, end closures, and other mating or moving parts	63

   2 Sealing Areas. For static seals without backup rings, O-ring grooves and mating sealing areas may be restored to meet the increased squeeze requirements in SAE Aerospace Recommended Practice ARP 1232, Gland Design, Elastomeric O-Ring Seals, Static Radial. However, restoration of the static sealing area to the dimensional requirements of MIL-G-5514 is an acceptable alternate which may require less work for

some repair actions. For restored dynamic seals, cylinder bore and piston O-ring gland dimensions shall not exceed the limits of MIL-G-5514 for radial clearance by more than 0.005 of an inch and reduction of cross-section squeeze by more than 0.010 of an inch when ESCL seals or T-rings are installed. These oversize dimensions are possible because both seals mentioned above are designed to work well in worn (and usually larger) glands. When O-rings are to be installed in the dynamic seals, the O-ring gland dimensions must meet the dimensional requirements of MIL-G-5514.

c. Replacement Parts. All metallic parts that fail to meet the inspection or reconditioning requirements shall be replaced with new, salvaged or reconditioned parts of the same size. Salvaged or reconditioned parts shall meet the inspection and reconditioning requirements specified above. All packings, O-rings, and backup rings shall be replaced with new packings, O-rings, and backup rings as applicable.

d. Reassembly. After all parts have been inspected and found to be satisfactory the actuator shall be reassembled. Torque all nuts, bolts, and fasteners in accordance with torque requirements on drawing. If no torque requirements are identified on drawings, torque fasteners to 90 percent of the maximum recommended seating torque listed in Table 556-10-1. If the strength of the fastener cannot be verified, select the torque value from the column for the lowest strength fastener which may be installed.

e. Test. Conduct hydrostatic and leakage tests per paragraph 556-2.3.4.5.

556-2.3.4.8 Assembly Instructions and Precautions for Sargent Actuators. This procedure applies to all Sargent actuators of a design similar to that shown in Figure 556-2-11, that is, actuators with sleeves which penetrate the body, and endcaps supported only by the sleeve. The reassembly of the rotary actuator must be done very carefully in order to preclude the development of leakage problems. The instructions and precautions in subparagraphs a. through f. supplement the existing repair and reassembly procedures. The key to accomplishing a successful reassembly of the actuator is to center the sleeves and maintain them in the centered position while mounting the endcaps and torquing the endcap bolts. This can best be accomplished by using the procedure in subparagraphs a. through f:

NOTE

This procedure assumes that the actuator as installed was properly shimmed, to limit rotation travel and bearing preloads, prior to disassembly. All shims removed during disassembly shall be reinstalled exactly in the same location during reassembly.

a. With the pinion in place and the pinion cover and bearing removed (for access), visually inspect the location of the sleeve. Slide the sleeve as required to ensure that it is centered with respect to the actuator housing. Improper orientation of the sleeve can also cause the sleeve to contact the pinion; rotate the sleeve as necessary to clear the pinion.

b. Maintain the sleeve in the centered position throughout assembly.

c. Mount the ported endcap. Bring the mounting screws up snug, finger-tight. Check to ensure the sleeve has not moved from the centered position.

d. Mount the unported endcap in a similar fashion. Bring the mounting screws up snug, finger-tight.

e. Torque the mounting screws of the endcaps in accordance with steps 1 through 4 to maintain the sleeve in the centered position and avoid distortion of the sleeve during torquing.

1 Torque the mounting screws of the unported endcap first to 50 in-lbs. Begin with an outside screw (the one nearest to the actuator holddown bolts) and then torque the diametrically opposite screw. Repeat for the remaining two screws.

2 Torque the mounting screws of the opposing ported endcap to 100 in-lbs following the foregoing sequence.

3 Retorque the screws of the unported endcap to 150 in-lbs similarly; continue alternating endcaps adding torque in 50 in-lbs increments until all mounting screws have been torqued to drawing requirements.

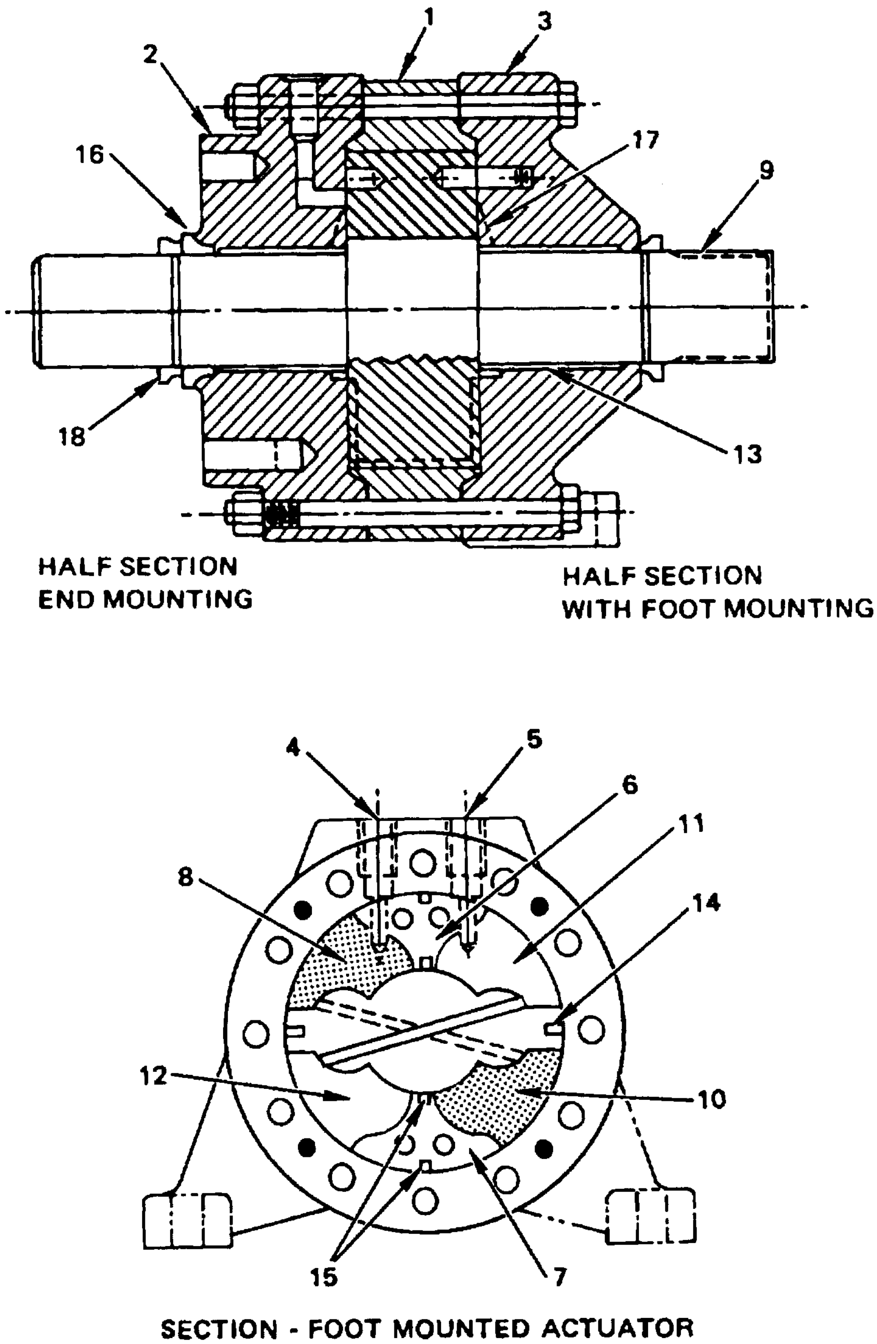
4 For double rack actuators, repeat steps e.1 through e.3 for the second set of endcaps.

f. When the endcap fasteners have all been torqued to the final value, visually inspect the position of the sleeves in relation to the pinion and verify that there is no contact.

556-2.3.4.9 Replacement Actuators. Whenever possible, replacement actuators and actuators for new applications shall be procured to the design requirements of MIL-A-24533.

556-2.3.5 VANE-TYPE ACTUATORS. A vane type rotary actuator converts hydraulic energy to rotary mechanical energy by direct application of fluid pressure to vanes fixed to the shaft to be rotated. Both single and double vane actuators have been used. A rotation up to approximately 110 degrees is available with a double vane actuator and up to 290 degrees can be obtained from a single vane actuator. The shaft is connected to the interfacing mechanism and applies the required output torque. This form of actuator serves the same purpose as the rack-and-pinion actuator.

556-2.3.5.1 Design and Operation. The vane type actuator (see Figure 556-2-12) consists of a cylindrical body (1), fitted with end caps (2) and (3), having fluid ports (4) and (5), and separated by abutments (6) and (7). Port (4) is connected to chamber (8), which, by means of a conduit through the wingshaft (9), connects to chamber (10). Port (5) is connected to chamber (11), which by means of another conduit through the wingshaft, connects to chamber (12). The wingshaft is supported at each end cap by bushing type bearings (13). Pressure loaded dynamic seals are provided at the vanes (14), abutments (15), wingshaft (16), and hub (17). The vanes, abutments, and wingshaft seals usually are made from a glass impregnated tetrafluorethylene material backed with a molded rubber seal. The hub seals, made from the same material, are supported by metal washers and are preloaded with a wave spring. Fluid under operating pressure enters inlet port (4), and causes an increase in pressure in chambers (8) and (10). Simultaneously the control valve has directed port (5) to open to sump, causing release of pressure in chambers (11) and (12). Fluid pressure on the vanes causes counterclockwise rotation of the wingshaft (9), exhausting fluid in chambers (11) and (12). Conversely, reverse action of the control valve will cause clockwise rotation. The torque developed by the actuator is proportional to the area of the vane and its moment about the shaft axis, and to the hydraulic fluid pressure differential on opposite sides of a vane. Speed of rotation is dependent upon the rate of flow of fluid. External stops (not shown) must be used to limit angular travel as the actuator abutments (6) and (7) are not designed as mechanical stops.



1	BODY	7	ABUTMENT	13	BUSHING
2	END CAP	8	CHAMBER	14	VANE SEAL
3	END CAP	9	WINGSHAFT	15	ABUTMENT SEALS
4	PORT	10	CHAMBER	16	SHAFT SEAL
5	PORT	11	CHAMBER	17	HUB SEAL
6	ABUTMENT	12	CHAMBER	18	EXTERNAL DIRT SEAL

Figure 556-2-12. Vane-Type Rotary Actautor

556-2.3.5.2 Internal Fluid Leakage. Vane actuators usually have some internal leakage. This leakage is a function of actuator size, fluid viscosity, operating pressure and the condition of the seal. Specific guidance on allowable leakage should be obtained from actuator drawings, technical manuals, and technical repair standards. If this information is not available NAVSEA should be contacted for specific guidance if leakage exceeds the values indicated in Table 556-2-9.

Table 556-2-9. MAXIMUM RECOMMENDED INTERNAL LEAKAGE FOR VANE-TYPE ACTUATORS

Torque Rating at System Operating Pressure (in-lb)	**Maximum Internal Leakage at System Operating Pressure with System Fluid at 25°C (77°F) and Above (ml/min)**
Up to 100,000	400
100,000 to 200,000	1100
Over 200,000	1500

556-2.3.5.3 Hydrostatic and Leakage Testing. Hydrostatic and leakage tests are required following overhaul or repair of actuators. Leakage and hydrostatic test may also be conducted to determine the need for overhaul.

a. Hydrostatic Tests. For hydrostatic test pressurize both ports simultaneously to one and one-half times the system operating pressure and maintain pressure for five minutes. During, and at the completion of the hydrostatic test, perform a visual inspection for damage and external fluid leakage. There shall be no loosening of bolts or evidence of damage to any part. There shall not be sufficient external fluid leakage to form a drop; a slight wetting of the surface sufficient to smear the fingers is not cause for rejection.

CAUTION

If only one port is pressurized the vane will move unrestrained and the impact of the vane against the abutment may shear the abutment dowel pins.

b. Leakage Tests. Internal leakage tests are conducted with system operating pressure applied to one port with the other port vented to an open container for collection of leakage. The actuator vane must be in contact with an abutment during the leakage test. See paragraph 556-2.3.5.2 for leakage requirements. After testing for leakage in one position rotate the actuator vane until the opposite abutment is reached and repeat the test with the other port pressurized.

556-2.3.5.4 Repair and Reconditioning. The internal parts of vane type actuators shall be subject to inspection in a manner similar to that described in paragraph 556-2.3.4.6 for rack and pinion type actuators. Similarly, the guidance for repair and reconditioning of rack and piston type actuators in paragraph 556-2.3.4.7 is generally applicable to vane type actuators. After repair of vane type actuators, the actuators shall be subject to hydrostatic and leakage tests as described in paragraph 556-2.3.5.3.

556-2.3.5.5 Replacement Actuators. In cases when it is not feasible to repair a vane type rotary actuator, particularly where the original type actuator is not available, the use of rack and piston type actuators to MIL-A-24533 is recommended.

SECTION 3.

PIPE, TUBING, HOSES, AND FITTINGS

556-3.1 PIPE, TUBING, AND FITTINGS

556-3.1.1 TYPES. Types of pipe, tubing, and fittings for surface ships are listed in MIL-STD-777. For submarines, approved types are listed in MIL-STD-438.

556-3.1.2 INSTALLATION AND MAINTENANCE. Guidance and requirements for the installation, inspection, and maintenance of piping and associated fittings are contained in NSTM Chapter 505, Piping Systems. . Fittings and other hydraulic system components should not be cadmium plated on surfaces that come in contact with the hydraulic fluid. For cleaning and flushing of hydraulic piping systems, see Section 7.

556-3.2 HOSES

556-3.2.1 TYPES. Hoses for hydraulic service are listed in Table 556-3-1. Note that hoses for petroleum-based fluids must not be used with phosphate ester fluids and that hoses for phosphate ester fluids must not be used with petroleum-based fluids. When hoses are installed between hydraulic accumulators and associated air flasks, use tetrafluoroethylene hose in accordance with SAE AS 604.

Table 556-3-1. HOSE TYPE APPROVED FOR HYDRAULIC SERVICE

HoseType	Size Range	Pressure
Petroleum and Water Base Fluids		
MIL-H-24135/1	-4 to -32	5000 to 1125
MIL-H-24135/2	-6 to -16	4500 to 2500
MIL-H-24135/3	-16 to -32	4000 to 2000
MIL-H-24135/4	-40 to -64	1200 to 600
MIL-H-24135/9*	-8 to -32	7500 to 3000
MIL-H-24135/10	-4 to -48	3000 to 450
MIL-H-24135/2	-4 to -32	2500 to 900
MIL-H-24135/3	-4 to -32	1000 to 350
MIL-H-24135/4	-40 to -64	1000 to 600
MIL-H-24135/11	-80 to -96	500 to 350
Phosphate Ester Base Fluids		
MIL-H-24135/6	-4 to -32	4500 to 1000
MIL-H-24135/7	-20 to -32	3000 to 2250
MIL-H-24135/8	-6 to -16	4500 to 2500
MIL-H-24135/12	-4 to -40	3000 to 300
MIL-H-24135/13	-4 to -32	5000 to 1125
High Pressure Air		
MIL-H-24135/5	-4 to -32	5000 to 1125

* The maximum pressure listed is for the smallest size hose and the minimum pressure is for the largest size hose. For a complete listing of pressure ratings, see S6430-AE-TED-010/Vol.1,(Technical Directive, Pumping Devices and Flexible Hose Assemblies) or the applicable military specifications.

556-3.2.2 INSTALLATION AND MAINTENANCE. Guidance and requirements for the installation and maintenance of flexible hose assemblies are given in **NSTM Chapter 505, Piping Systems** . If hoses are flushed with water before installation they must be blown dry with dry air. Rather than water, use filtered system fluid for flushing following the general guidance in MIL-STD-419.

556-3.2.3 SERVICE LIFE. All flexible rubber hose connections shall be replaced every 7 years with the exception of MIL-H-24135/3, size-24 hose. When used in 3,000 lb/in^2 hydraulic system applications subject to pressure cycles of more than 1,500 lb/in^2 , MIL-H-24135/3, size-24 hose shall be subject to the following service-life limitations:

a. Service life shall be limited to 15 months for applications subject to 10 or more pressure cycles per hour

b. Service life shall be limited to 30 months for applications subject to 1 to 10 pressure cycles per hour.

c. If Aeroquip FC-254 hose with assorted end fittings is installed in 3,000 lb/in^2 hydraulic systems, the service life shall be 7 years.

556-3.3 PROTECTIVE SPRAY SHIELDS

556-3.3.1 Protective covers, usually referred to as spray shields, are discriminatively used in hydraulic fluid piping systems to prevent ignition of fluids that might escape from a mechanical joint and impinge on a hot surface. These shields are also used for hydraulic fluid system applications where direct fluid impingement on operators, critical or sensitive equipment, exposed electrical wiring, or nonexplosion-pro of motors, may occur. Complete information on the use of spray shields, including hazard definitions, preferred piping arrangements, applicability, installation procedures, and procurement details is provided in NSTM Chapter 505, Piping Systems. The applicability of spray shields to fossil-fueled and nuclear-powered surface ships is clearly defined. Unless requirements are already designated in the applicable system or component drawings, submarine hydraulic systems should also be provided with shields in accordance with the respective requirements for fossil-fueled and nuclear-powered surface ships.

556-3.4 UNIONS

556-3.4.1 Unions are designed to seal against leakage, under operating conditions, by a metal-to-metal contact (ground joint) or, in the case of high pressure service such as a gas or hydraulic system, by an O-ring seal. Details on the different types of unions and particular emphasis on allowable angular and axial misalignment requirements for the O-ring unions are provided in NSTM Chapter 505, Piping Systems. Failure of high pressure O-ring union connections on several ships has been attributed to improper pipe fitting and joint assembly procedures. Excessive misalignment and gaps will result in extrusion of the O-ring which will eventually either blow-out or get nibbled sufficiently to cause serious leakage. Often the wrong action is taken in that the nut is slugged an additional half or full flat in an attempt to stop the leak. This procedure usually results in a damaged or galled union assembly, and only a temporary (if any) improvement in seal leakage. Leaking joints should be disassembled and reinspected to ensure that the proper alignment conditions have been met. If misalignment is obvious before unscrewing the nut, provide jacking force as feasible to reduce related strains and loads on nut threads. Before reassembly, always replace the O-ring. To minimize the potential for galling, before assembling a union apply liberal amounts of anti-galling compound per Commercial Item Description (CID) A-A-59004 (NSN 9150-01-446-2164) to the following areas of the union: (1) the nonthreaded surface (shoulder) where the nut mates with the union’s tail piece and (2) the external threads on the thread piece (male end of the union). To prevent fluid contamination, avoid getting any anti-galling compound or thread lubricant inside the piping. When anti-galling compound per CID A-A-59004 is not available, applicable thread lubricants listed in NSTM Chapter 075 may be substituted. Torque to drawing requirements. Do not overtorque. Do not slug nut.

556-3.5 CONNECTOR TUBES

556-3.5.1 CONNECTOR TUBES (FERRULES, QUILLS AND TRANSFER TUBES). These connector tubes with an external O-ring gland in each end are used in place of face seals, primarily as an interface between hydraulic valves and subplates on submarines. The seal is not dependent upon proper tightening of valve hold-down bolts for effective sealing. Connector tubes may also be used for internal connections within hydraulic components.

556-3.5.1.1 MIL-C-24714 Connector Tubes. General requirements for the tubes are contained in MIL-C-24714. Part numbers and dimensions for specific tubes are contained in MIL-C-24714/1. MIL-C-24714/1 also contains the dimensions for the counterbores into which the tubes are installed. Tubes with these dimensions have been used on some of the hydraulic valves for SSN 688 class and later submarines. However, not all the connector tube designs on SSN 688 and later class submarines are in accordance with MIL-C-24714/1.

556-3.5.1.2 Connector Tube Leakage Problems. In a few cases, leakage problems have been experienced with valves containing these connector tubes. Usually such valves are ones subject to a significant number of pressure cycles such as pump bypass (unloading) valves or valves for steering and diving control surfaces. The leakage, really weepage, is less than a drop per hour and constitutes a housekeeping rather than an operational or safety problem. Corrective action is not recommended unless leakage exceeds one drop per six hours.

556-3.5.1.3 Correcting Connector Tube Leakage Problems. The O-ring squeezes for most connector tubes used to date are based on MIL-G-5514 O-ring gland dimensions; this is the case for MIL-C-24714 Connection Tubes.[*] In many cases, improved performance can be obtained by increasing the O-ring squeeze. This is accomplished by an increase of 0.001 to 0.002 inches in the gland groove OD. The male gland groove OD which should be used is dimension ″F″ per SAE AS 4716. The connector tube diameter should not be changed. If leakage is experienced, replacement connector tubes with slightly increased O-ring squeeze may be installed. This may be accomplished as an alteration-equivalent-to-repair and no waiver approval or documentation of the change is required. Interchangeability of connector tubes is not affected by this modification.

SECTION 4.
VALVES

556-4.1 GENERAL

556-4.1.1 Valves are used in hydraulic systems to control the rate of flow, the direction, and the pressure of the fluid. Valves are usually named or identified by the function, capacity (size), and pressure rating. In some instances the identity of the valve may reflect a feature of its construction such as a needle valve characterized by a long tapered valving element. There is such a wide variety of valves that it would be impossible to describe all the types installed in shipboard systems. A few of the more common valves and their functions are discussed in this section.

[*](MIL-C-24714/1 dimensions will not be revised per the changes in this paragraph because it is being converted to an SAE standard, where the increased squeeze will be incorporated into the SAE part standard.)

556-4.2 FLOW CONTROL VALVES

556-4.2.1 The most basic flow control valve is the simple stop valve that opens or closes a line to the flow of fluid. The most common types of stop valves are globe valves, gate valves, needle valves, and plug cocks. The needle valve may be used as a stop valve and for throttling the flow of fluid. However, it does not compensate for pressure, temperature, or viscosity changes and, therefore, is not generally used when accurate control of flow is required. More complex types of flow control valves which compensate for pressure variations generally are adjustable over a range of flow rates. These pressure-compensated valves generally are not used as stop valves and the flow rate generally is adjusted for the particular application. These valves may incorporate a check valve which will allow full flow in one direction and restricted flow in the other direction.

556-4.3 RELIEF VALVES

556-4.3.1 USAGE. The most common type of pressure-control valve is the relief valve. Relief valves generally are used to provide overload protection in a system or to limit the force put out by a hydraulic actuator.

556-4.3.2 RELIEF VALVE TERMINOLOGY. A description of terms in common usage is presented here because of the importance of relief valves to the satisfactory and safe operation of a system and because detailed instruction for maintenance of these valves frequently is unavailable in equipment manuals.

a. Back-pressure. The maximum pressure at the outlet of the valve during operation. Back-pressure is caused by the static head plus the dynamic flow losses of the relief valve discharge piping.

b. Cracking or Lifting Pressure (Set Pressure). The difference between inlet and outlet pressure at which flow begins to pass through the valve.

c. Full Flow Differential Pressure. The difference between inlet and outlet pressure at full flow (rated capacity) of the valve. Also known as accumulation pressure or rated flow differential pressure. (For a properly sized relief, this pressure should not exceed system operating pressure by more than 25 percent.)

d. Rated (Flow) Capacity. The flow rate which the valve should pass without exceeding the full flow differential pressure.

e. Minimum Reseat Pressure. The minimum acceptable reseat pressure with no back pressure on the relief valve outlet. (Generally the reseat pressure should not be less than system pressure.)

f. Nominal Set Pressure. The nominal set pressure will be the approximate cracking pressure of the valve and is defined as the midpoint between the minimum reseat pressure and the full flow differential pressure.

g. Set Pressure Range. The range over which the set pressure can be adjusted with the installed spring.

h. Effect of Back-Pressure on Valve Setting. The setting of a relief valve is affected by the back-pressure on the valve drain port. For example, a relief set to crack at 200 lb/in^2 g on a test bench with no back pressure, would not crack until inlet pressure reached 260 lb/in^2 g if the valve drain has a back-pressure of 60 lb/in^2 g. In addition, any dynamic flow loss in the drain piping would also increase the relief valve setting.

   1 Some types of relief valves, as shown in Figure 556-4-1, have internal drains where the drain is connected, internal to the valve, to the relief valve outlet port. With these types of valves, the back-pressure on the drain port is the same as the back pressure at the relief valve outlet.

   2 The effect of back-pressure can often be reduced by using an externally drained type of relief valve as shown in Figure 556-4-2. This type of valve is often used as a sequence valve in industrial applications but can be used as a relief valve when it is necessary to minimize the effect of back-pressure. Back-pressure at

the outlet of an externally drained relief valve does not affect the valve setting. The drain port should be connected to an unpressurized tank or, if this is not feasible, to a line not subject to high dynamic flow losses such as a vent and replenishing line.

i. Reset Pressure. After a relief valve opens, the valve tends to stay open due to flow forces even though system pressure has dropped below the cracking pressure. For high pressure reliefs, the reseat should not be less than 85 percent of the cracking pressure, although a reseat not less than 90 percent of cracking pressure is preferred. For reliefs set at pressures below 150 lb/in^2 , a reseat pressure of less than 85 percent of the cracking pressure may be acceptable in some applications. For applications where the reseat pressure is critical, the setting procedure for the relief valve should include a determination of the minimum reseat pressure.

j. Response Time. Poppet type valves generally will have a shorter response time than spool type valves. However, the spool type usually has better stability and accuracy of operation and adjustment. Similarly the direct acting relief usually has a faster response than the pilot-operated type, but accurate adjustment of the direct-acting type is more difficult.

k. Internal Leakage. Most relief valves will be subject to a slight internal leakage which will increase as system pressure approaches the cracking or lifting pressure. Therefore, the cracking pressure is often defined as the pressure at which some specified leakage or flow occurs. Similarly, the reseat pressure is often considered to be that pressure at which flow or leakage drops to a certain established value. Leakage is a function of fluid viscosity; therefore, leakage will vary with the fluid used and the temperature of the fluid. See paragraphs 556-4.4 through 556-4.4.5 for information regarding application of correction factors when testing with various fluids.

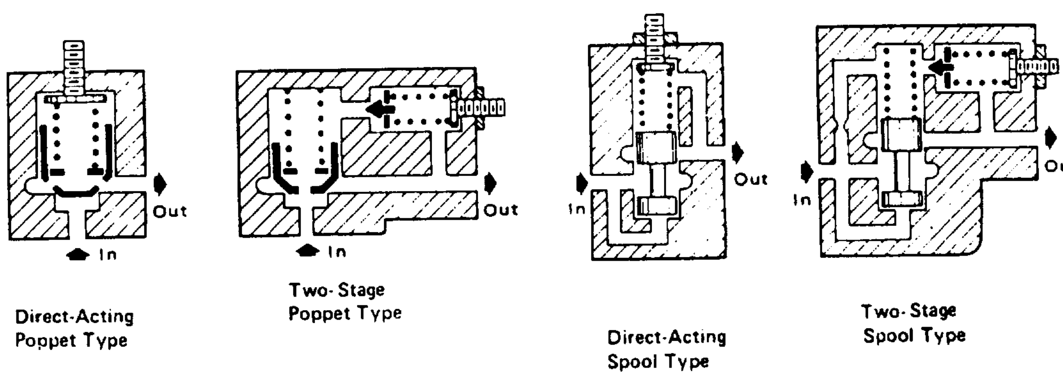


Figure 556-4-1. Types of Internally Drained Relief Valves

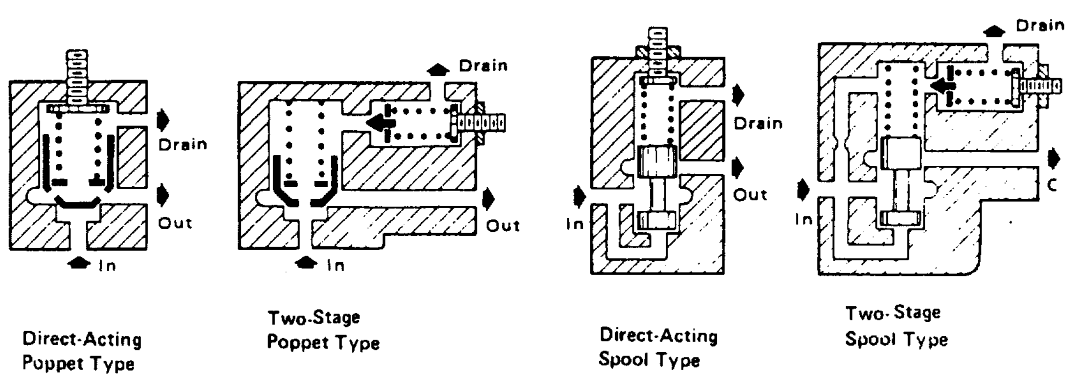


Figure 556-4-2. Types of Externally Drained Relief Valves

556-4.4 VALVE LEAKAGE

556-4.4.1 GENERAL. Valve leakage is usually dependent upon fluid viscosity and the pressure differential across the leakage path. Therefore leakage criteria shall include both the test pressure and the fluid viscosity. Often fluid and fluid temperature are specified rather than fluid viscosity. This method is less precise since the viscosity for a particular fluid will vary within a specified range. Fluid viscosity requirements can be changed; for example, Table 556-5-1 indicates that the viscosities of MIL-H-17672 fluids were increased approximately 20 percent by Revision C, Amendment 1. Fluid viscosity data is provided in Section 5.

556-4.4.2 LEAKAGE RATE CORRECTION FACTORS. Leakage rate correction factors are required in the following cases:

a. Testing with a fluid other than the fluid upon which the leakage rate is based.

b. Testing at a fluid viscosity (temperature) other than the viscosity upon which the leakage rate is based.

c. Testing with a fluid for which the viscosity has been changed since the leakage rate was established.

556-4.4.3 CALCULATION OF LEAKAGE CORRECTION FACTORS. It is generally preferable to test with the specified fluid; however, a valve whose leakage rate is specified at a particular viscosity (or fluid and temperature) can be tested with another viscosity fluid (different fluid or temperature) provided a correction factor is applied to the leakage rate. The following correction factor applies:
q’ = q(v/v’) p’/(p)
Where

q’ = corrected leakage rate for test fluid being used

q = acceptable leakage rate as specified for a particular valve

v = viscosity in centistokes of fluid for conditions at which valve leakage is specified

v’ = viscosity in centistokes of fluid for conditions under which valve is being tested

p = specified test pressure upon which leakage rate is based

p’ = pressure at which test is actually conducted
If test is conducted at the specified pressure

= 1 and the correction factor is simply q’ = q v/(v’) example:

(a) Maximum allowable leakage is specified as 5 ml/minute with 2110TH fluid at 40° C (104° F) and 1,500 lb/in^2
.

(b) Test fluid is 2075TH at 40° C (104° F) and 1,500 lb/in^2

(c) q = 5 ml/minute (as specified).
v = 46 centistokes (from Table 556–5–1)
v’ = 32 centistokes (from Table 556–5–1)

(d) q’ = q v/(v’) = 5 ml/min x 46/(32)
q’ = 5 ml/min (1.4375)
q’ = 7.2 ml/minute

(e) A leakage rate of 7.2 ml/min is accepatable when testing with the lower viscosity 2075TH fluid at 40° C (104° F).

556-4.4.4 REVISED LEAKAGE RATES DUE TO CHANGES IN VISCOSITY OF MIL-H-17672 FLUIDS. As explained in paragraph 556-5.6.2, MIL-H-17672 fluids procured in 1982 and later are approximately 20 percent more viscous than earlier fluids with the same symbol (2075TH, 2110TH, 2135TH). For surface ship hydraulic systems, no general changes in requirements or documentation were promulgated. Therefore, the original leakage rates for valves can be used. For submarines, the fluid used in many systems was changed. (See paragraph 556-5.6.3 for system fluid recommendations.) At the same time guidance was provided for revising leakage requirements. This guidance is contained in Table 556-4-1. Generally guidance in technical manual sections prepared in 1982 or earlier refer to original fluid viscosities. Where applicable, guidance in Table 556-4-1 may be used in lieu of calculating correction factors as described in paragraph 556-4.4.3.

556-4.4.5 SPECIFYING LEAKAGE REQUIREMENTS. The following guidance shall be followed in specifying leakage requirements.

a. Tie acceptable leakage rates to a specific viscosity in centistokes. For example, leakage shall not exceed 5 ml/min when tested at 3,000 lb/in^2 with fluid having a viscosity of 68 centistokes.
b. If possible, base leakage requirements on the viscosity equivalent to the ISO viscosity grade at 40°C (104°F) for the fluid used in the system. For example, the ISO viscosity grade for the new 2135TH fluid is 68, meaning the fluid viscosity at 40°C (104°F) will be 68 centistokes, plus or minus 10 percent.
c. If requirements are stated in terms of a fluid, rather than a specific viscosity, the viscosity grade of the fluid will be included. For example, leakage at 40°C (104°F) with 2075TH (ISO VG 32) shall not exceed 3 milliliters per minute.
d. State temperatures in degrees Celsius followed by the equivalent Fahrenheit temperature in parentheses.

556-4.4.6 RELIEF VALVE SETTINGS. The purpose of a relief valve is to limit maximum system pressure to a safe value. In selecting the nominal set pressure of the relief valve one must consider the operating characteristics of the valve and the system which it is to protect.

556-4.4.6.1 Design Considerations. As discussed under operating characteristics, the differential pressure across the valve at rated flow may be approximately 10 percent above the cracking pressure while the reseat pressure may be 10 percent below the cracking pressure. If the valve is to reseat at or above the normal maximum system operating pressure, the maximum differential pressure across the valve at rated flow will be 120 to 125 percent of the normal system operating pressure. If this is not acceptable, a lower reseat must be accepted or a valve with a narrower operating range must be selected.

a. In past designs, the nominal set pressure (cracking pressure) for hydraulic relief valves often has been specified as approximately 110 percent of the nominal or maximum system operating pressure while the more important considerations of maximum full flow pressure and reseat pressure have often been ignored.
b. For new designs, relief valves will have operating characteristics and settings in accordance with Figure 556-4-3 which is based on MS 18282 (SHIPS). Note that two sets of operating characteristics are depicted; one for operating pressures from 10 to 100 lb/in^2 g and another for pressures from 100 to 3,000 lb/in^2 g. For operating pressures above 3,000 lb/in^2 g, the following operating characteristics apply:
    1 Maximum differential pressure (lb/in^2 d) at rated flow is limited to 125 percent of the system operating pressure

2 Minimum reseat pressure is 50 lb/in^2 above the system operating pressure

3 Nominal set pressure is midway between the maximum differential pressure and the minimum reseat pressure.

Table 556-4-1. REVISED LEAKAGE REQUIREMENT FOR SUBMARINE HYDRAULIC VALVES USING MIL-H-17672 FLUIDS

Original Leakage		Revised Leakage Requirement		
FLUID	**TEMP**	**FLUID**	**TEMP**	**ALLOWED LEAKAGE**
2075TH (MIL-H-17672C and earlier)	100°F	2075TH (ISO VG 32)	40°C (104°F)	Same as original leakage
2110TH (MIL-H-17672C and earlier)	100°F	2075TH (ISO VG 32)	40°C (104°F)	33% increase over original leakage
2110TH (MIL-H-17672C and earlier)	130°F	2075TH (ISO VG 32)	40°C (104°F)	75% of original leakage

* Leakage requirement in technical documents dated before 1983 which refer to MIL-L-17672 fluids may be assumed to refer to the Rev. C. and earlier viscosities. References to the new viscosity fluid should identify the ISO viscosity grade (VG) of the fluid. (See paragraph 556-4.4.4).

556-4.4.6.2 Determining Setting. Relief valve pressure settings may be obtained from system diagrams and their tables, technical manuals, ship information books, and shipyard test forms which are applicable to the system in which the relief valves are installed. If the specific setting cannot be located or if only the nominal set pressure (or cracking pressure) is given, Figure 556-4-3 may be used to determine maximum rated flow differential pressure and minimum reseat pressure. If the range of operating characteristics shown in Figure 556-4-3 is too broad to meet system performance requirements, a narrower band of characteristics shall be used to set the valve as necessary to achieve satisfactory system performance.

Example 1: System operating pressure is 2000 psig. Going up vertically from 2000 on the x axis (maximum operating pressure) to an intersection with the minimum reseat, nominal set pressure and maximum full flow differential pressures lines we read approximately 2010, 2330 and 2650 psi respectively for the values taken from the y (vertical) axis. (Note: A slight error in reading the value is not important. A maximum full flow pressure between 2600 and 2675 would be acceptable. The minimum reseat should be slightly higher than the maximum operating pressure.)

Example 2: The system diagram specifies a nominal set pressure of 55 psig. Using the 10-100 psi curves find the intersection of the set pressure curve with 55 psi on the y (vertical) axis. From this intersection go vertically up to the maximum full flow pressure curve to obtain a value of 65 psi on the y axis. Go vertically downward to intersect the minimum reseat pressure line and read 43 psi on the y axis.

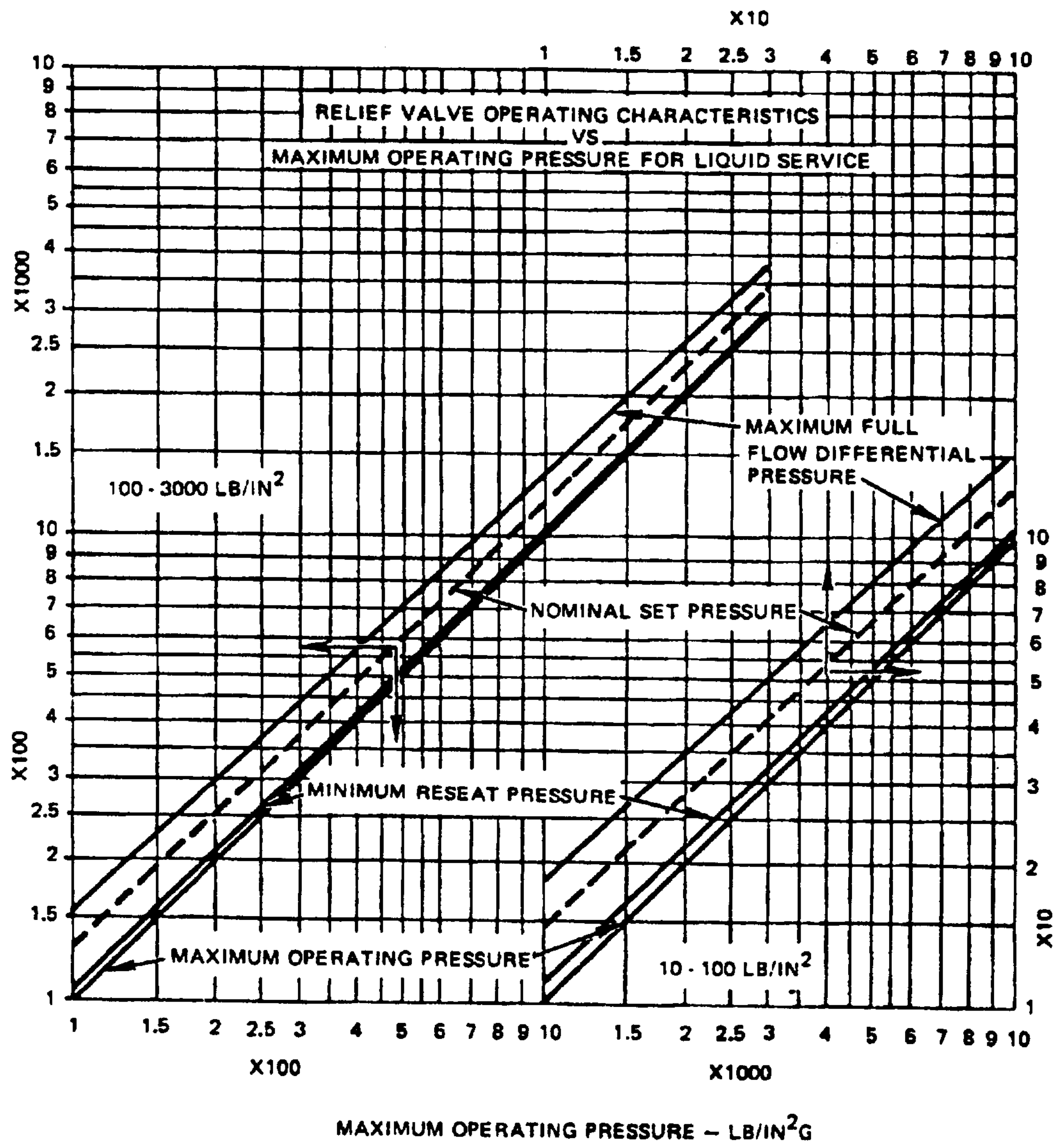


Figure 556-4-3. Relief Valve Settings Based on Maximum System Operating Pressure

556-4.4.6.3 Recommended Test Stand Setting Procedure. A recommended procedure for setting hydraulic relief valves consists of setting the valve to reseat slightly above the specified minimum reseat pressure and then verifying that the valve will pass rated flow without exceeding the maximum specified differential pressure. After the valve has been adjusted to meet the above requirements, the leakage can be measured at system pressure. A recommended test circuit is shown in Figure 556-4-4. The recommended tests, listed below, are intended for use as general guidance and in situations where no other requirements are available. This guidance does not supersede any Technical Repair Standards or other specified criteria.

a. Reseat Test With outlet of the relief unrestricted (V_1 and V_2 open or P_2 disconnected), set the test stand to deliver at or slightly above the required reseat pressure. Back off on valve adjustment until valve relieves, then slowly adjust valve until it just seats. Check setting by increasing pressure until rated flow is obtained (or maximum test stand capacity if less than rated flow) and then slowly reduce pressure to the minimum reseat pressure. Wait one to three minutes and then measure leakage from P_2 , or from V_2 , after closing V_1 . The relief valve may be considered to be reseated if leakage does not exceed the allowable leakage specified on the system relief tables by a factor of more than five. The allowable leakage specified on system tables is the leakage at operating pressure and not reseat pressure leakage.

b. Rated Flow Test. With V_2 closed, increase test stand output until the rated flow of the relief is obtained. Setting is satisfactory if the differential pressure obtained does not exceed the maximum rated flow differential pressure. The inlet and outlet gages from which the differential pressure is obtained should be mounted within one foot of the valve being tested to minimize the increase in differential pressure due to flow losses in the piping. When the test stand is not capable of producing the approximate rated flow, the differential pressure should be measured at three flow rates and the rated flow differential pressure determined by extrapolation of the flow-differential pressure curve. If the actual flow rate is less than 80 percent of the rated flow, it is recommended that differential pressure be measured at full two-thirds and one-half capacity of the test stand.

c. Leakage Test. The leakage test provides an indication of what the leakage through the valve will be under normal operating conditions. The test pressure is system pressure, or in the case of return line relief valves, the test pressure is normal return line pressure. With V_1 closed and V_2 open, reduce supply pressure well below the specified system pressure. Slowly increase pressure to the specified test pressure, wait one to three minutes and measure leakage.

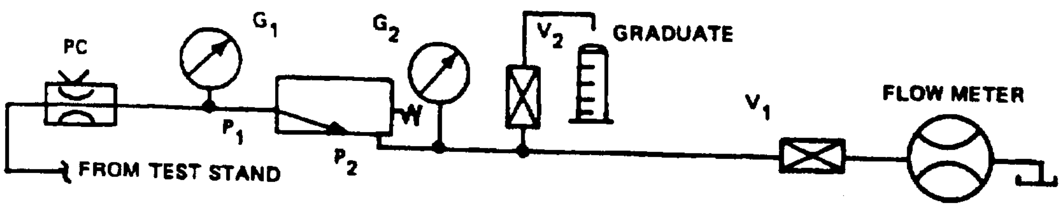


Figure 556-4-4. Recommended Test Circuit for Relief Valves

556-4.4.6.4 Alternate Setting Procedure. When a test stand is not available for the setting and testing of relief valves the following procedure may be used. Pressure should be applied to the inlet of the relief and the valve adjusted so that it starts to lift (crack) at the nominal set pressure. The nominal set pressure is specified on system relief valve tables and normally will be midway between the reseat pressure and the maximum rated flow differential pressure. When using this method the lifting (cracking) pressure must be held within rather tight tolerances to ensure that reseat and rated flow differential pressure requirements will be met. For this reason, a tolerance of +5 lb/in^2 for settings up to 500 lb/in^2 and a tolerance of +2 percent for settings above 500 lb/in^2 is recommended. In addition, reseat pressure and leakage at system pressure should be verified, if possible.

556-4.4.6.5 Relief Valve Tagging Requirements. When relief valves are set, tags shall be attached to the valves which contain as a minimum the following information:

a. Date set

b. Name of activity and person conducting or witnessing test

c. Setting and test conditions Testing of valves installed in a system is not always possible and the test results in an installed system may vary from test bench tests due to several factors. In a bench test, pressure acting on the return port should be minimal while in a system the outlet port may often be subject to a significant fixed or variable pressure. (See paragraph 556-4.3.2 for the effect of back-pressure on relief setting). Flow rate and fluid viscosity, which are difficult to measure during system testing, will affect observed pressures.

556-4.4.6.6 Preventing Inadvertent Relief Valve Adjustment. Some of the relief valves used in hydraulic systems have internal adjustments which prevent adjustment once installed in a system. However, most commercial valves are equipped with external adjustments. When valves with external adjustments are installed, it is usually desirable to protect the valves from inadvertent or unauthorized adjustment. This can often be accomplished by drilling a small hole through the adjustment knob for lockwiring the knob after the proper setting is obtained.

556-4.5 CHECK VALVES

556-4.5.1 Check valves are used in hydraulic circuits to allow flow in one direction only. The most common types use either a ball or cone for the sealing element.

a. Check valves frequently are used in combination with other types of flow control valves to allow free flow of fluid in one direction while controlling the flow in the other direction; for instance, to extend a cylinder slowly and retract it rapidly.

b. Maintenance of check valves is mainly concerned with checking that all the parts are clean and in good condition. Any imperfections of the ball or cone or of the seat should be corrected as soon as noticed. Leakage through the valve will increase quite rapidly due to erosion and the heat being generated as the fluid escapes past the valve seat.

556-4.6 SEQUENCE VALVES

556-4.6.1 Sequence valves control the sequence of operation between two branches of a circuit. A sequence valve is somewhat similar to a relief valve except that, after the set pressure has been reached, the sequence valve diverts the fluid to a second actuator or motor to do work in another part of the system. The relief valve simply dumps the fluid to tank or to a low pressure circuit. Pressure setting procedures for sequence valves are similar to procedures outlined for relief valves.

556-4.7 REPLENISHING VALVES

556-4.7.1 Hydraulic systems having a closed loop circuit have replenishing valves to ensure that the hydraulic pump has an adequate supply of fluid at all times. A closed loop circuit may have numerous places where fluid is lost from the high pressure circuit to the reservoir or to leakage outside the system. Also, fluids compress slightly under pressure, and the additional fluid to compensate for the compression must be added to the intake side of the hydraulic pump. To provide this make-up fluid, replenishing valves are installed in the circuits. The replenishing valve is basically a check valve named for the function it performs.

556-4.8 UNLOADER VALVES

556-4.8.1 Unloader valves are used to direct the flow of fluid from a pump to the work until a predetermined pressure is attained, then to discharge the flow back to the tank at a low pressure until such time as the flow is again required.

a. The return line should be piped directly to the reservoir and discharged into the tank below the minimum operating oil level and should be located as far as possible from the pump inlet.

b. Indication of unloader valve trouble is:

    1 No pressure

    2 Failure to load or unload

3 Failure to load or unload at same pressures

4 Pressure not responding to adjustment

c. Air leaks in the pump will cause faulty pump operation, which in turn causes faulty valve operation. This is indicated by sharp cracking noises in the line, and violent fluttering of the pressure gage needle.

556-4.9 DIRECTIONAL VALVES

556-4.9.1 Directional valves are used to direct the flow of fluids in a system and thereby control the action of actuators energized by the fluid pressure.

a. The most commonly used directional valve is the four-way valve which derives its name from the four directions of fluid flow to or from the valve ports. The pressure or pump port receives fluid from the fluid supply. Each of the two work ports connects to one side of the actuator doing the work. The fourth port connects to the reservoir and returns fluid there when the fluid is no longer required to pressurize the actuator. A spool or piston within the valve body has the necessary passages or lands to connect the various ports in various combinations depending upon the position of the spool in the valve body. The valve spool may be positioned by various means. The most common methods are hand operated, hydraulic operated, and electrical solenoid operated.

b. Four way directional valves are generally either closed-center type or open-center type. In a closed-center valve the port connected to the pressure source is closed off when the valve spool is in the center position. The fluid supply must then be diverted from the directional valve by stopping the delivery or the pump, by passing the fluid over a relief valve or diverting the fluid to an accumulator. In an open-center valve when the spool is in the center position the fluid supply port is connected directly to the return of dumping port. With this type valve, the pump is not required to do any significant work while the valve is in the center position. However, there is then no system pressure available to work other actuators.

556-4.10 SERVO VALVES

556-4.10.1 Servo valves are basically a variation of an electrically operated directional valve. Most servo valves use a small electrical signal to control a relatively large flow of fluid. Many servo valves have integral amplifiers which use the fluid pressure to control the main valve spool. Servo valves are of such a wide variety of designs and types that no general description of operation is considered appropriate. Maintenance and repair procedures should be obtained from the applicable equipment manuals. Many servo valves have hydraulic amplifiers controlled by electrical devices with relatively low force capability. The servo valve is therefore particularly vulnerable to improper operation due to contamination. Operators should be especially careful to maintain clean hydraulic fluid in any system using a servo valve.

556-4.11 FLOW RESTRICTORS

556-4.11.1 LEE JET RESTRICTORS. The flow of fluids to many hydraulic components, particularly in submarine hydraulic systems, is regulated by calibrated fluid restrictors. These devices, called Lee Jets, control the speed of hydraulically operated components. Lee Jets are installed in special control valves and in housings such as shown in Figure 556-4-5 and Figure 556-4-6. The fluid resistance of each Lee Jet is defined in terms of liquid ohms, (lohms) a unit of measurement devised by the Lee Company to be analogous to electrical resistance. One lohm of fluid resistance will flow 100 gal/min of water with pressure drop of 25 lb/in 2 at 80°F. The higher the lohm rating, the greater the resistance to fluid flow.

556-4.11.2 STANDARD LEE JETS. The standard Lee Jet restrictor consists of a calibrated orifice assembled between a pair of screens to prevent clogging and a sealing device called an expander pin (Figure 556-4-7). As a result of the high exit velocities induced through the orifice, the downstream screen has a tendency to erode due to the direct impingement of fluid on the screen.

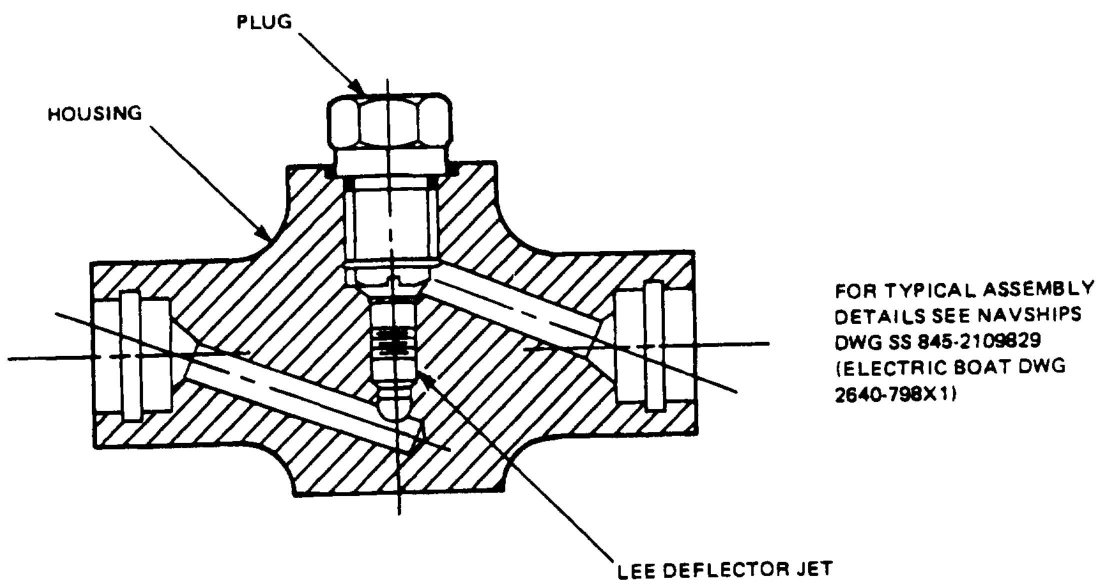


Figure 556-4-5. Lee Jet Housing Using Expander Pin

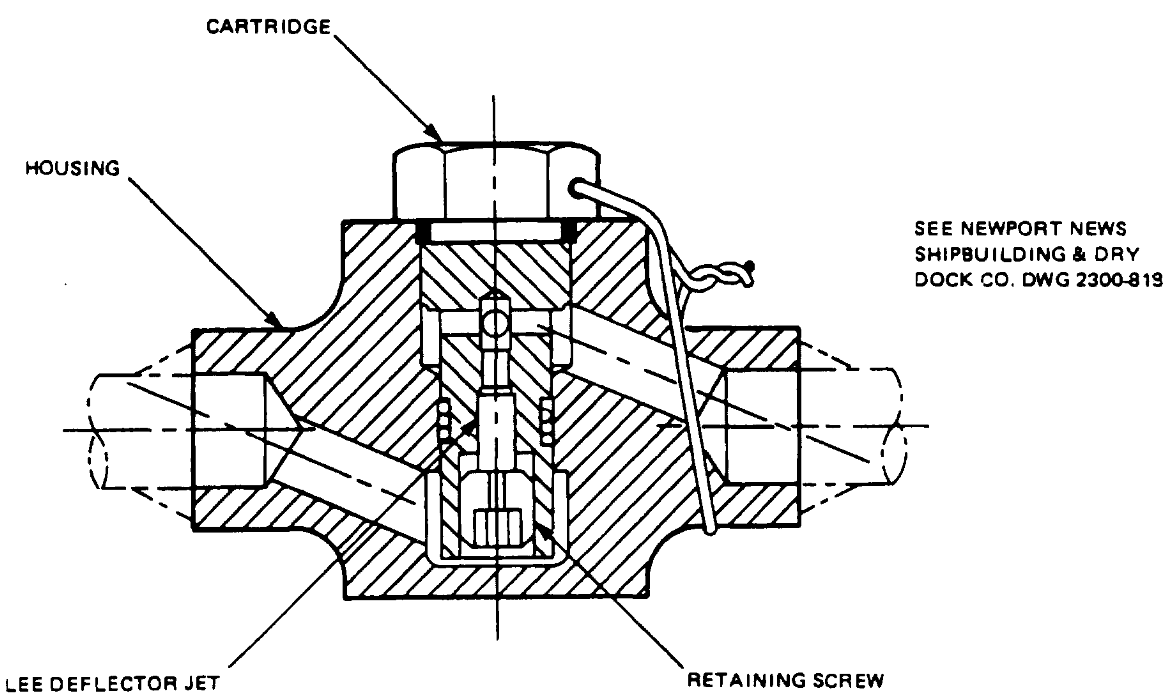


Figure 556-4-6. Cartridge Lee Jet Housing Not Using Expander Pin

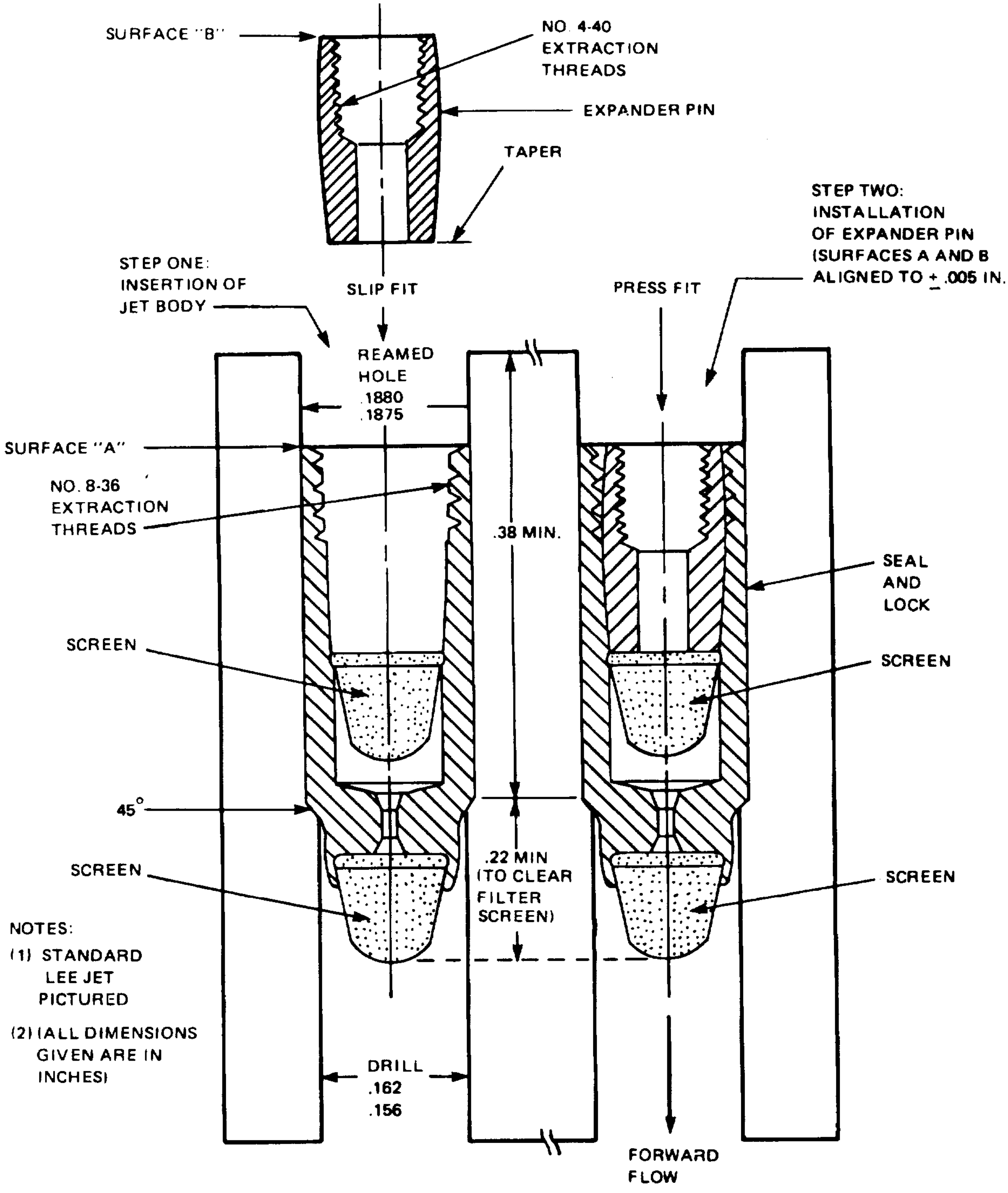


Figure 556-4-7. Typical Installation and Removal of Lee Jet Restrictions

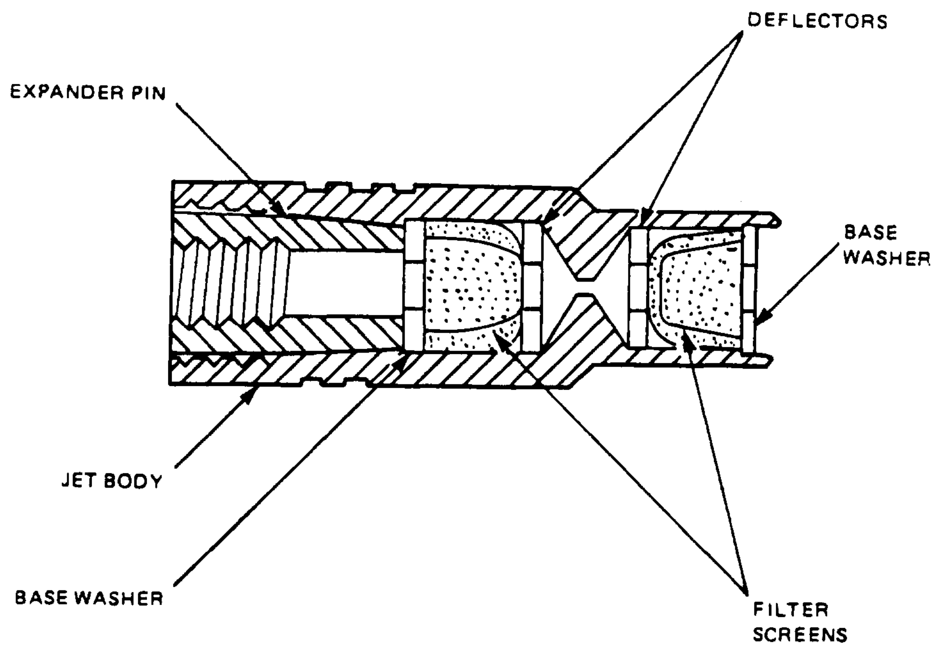


Figure 556-4-8. Lee Deflector Jet

556-4.11.3 LEE DEFLECTOR JETS. To prevent erosion of the screen in the standard Lee Jets, deflector bars were added adjacent to the screen to deflect the fluid stream away from the screen. This modification of the standard Lee Jet restrictor is known as the Lee Deflector Jet (Figure 556-4-8). Where standard Lee Jets are installed and replacement is necessary, use Lee Deflector Jets of the same lohm rating. Lee Deflector Jets are interchangeable with standard Lee Jet restrictors and are available in standard sizes as indicated Table 556-4-2. Lee Deflector Jets of higher or lower lohm ratings than specified for a given application may be substituted to achieve the desired speed control.

Table 556-4-2. LEE DEFLECTOR JET IDENTIFICATION

Lee & Deflector Jet Part No.		**Marking**		**Lohm Rating (±5%)**	**National Stock Number**
Original	New	Old (OL)	New		
EX 36523	JEDX 0500440A	N/A	N/A	300	Not Available
EX 36524	JEDX 0500430A	N/A	N/A	400	1H4730-00-089-2647
EX 36525	JEDX 0300000A	39	500L	500	1H4730-00-089-2654
EX 36526	JEDX 0300050A	47	750L	750	1H4730-00-089-2662
EX 36527	JEDA 1875100D	55	100D	1000	1H4730-00-089-2667
EX 36528	JEDA 1875150D	67	150D	1500	1H4730-00-089-2671
EX 36529	JEDA 1875200D	77	200D	2000	1H4730-00-089-2672
EX 36530	JEDA 1875300D	95	300D	3000	1H4730-00-089-2676
EX 36531	JEDA 1875400D	110	400D	4000	1H4730-00-089-2680
EX 36532	JEDA 1875500D	122	500D	5000	1H4730-00-089-2683
EX 36533	JEDA 1875600D	134	600D	6000	1H4730-00-089-2690
EX 36534	JEDA 1875700D	145	600D	7000	1H4730-00-089-2691
EX 36535	JEDA 1875800D	155	800D	8000	1H4730-00-089-2693
EX 36536	JEDA 1875900D	164	900D	9000	1H4730-00-089-2695
EX 36537	JEDA 1875100H	173	100H	10000	1H4730-00-089-2696
EX 36522	JEDA 1875150H	212	150H	15000	1H4730-00-089-2636

Table 556-4-2. LEE DEFLECTOR JET IDENTIFICATION - Continued

Lee & Deflector Jet Part No.		Marking		Lohm Rating (±5%)	National Stock Number
EX 36538	JEDA 1875200H	245	200H	20000	1H4730-00-089-2697
EX 36539	JEDA 1875300H	300	300H	30000	1H4730-00-484-5969

* See paragraph 556-4.8.1

** Lohm rating is the same for both directions of flow. Intermediate sizes of restrictors are made by the Lee Company but not stocked in the supply system.

556-4.11.4 LEE VISCO JETS. Lee Visco Jets (Figure 556-4-9) are used in a few specialized hydraulic system applications, primarily where very high fluid resistance (high lohm rating) is required. They employ specially designed discs which make up a visco stage to aerate a complex path for the fluid. This enables Lee Visco Jets to maintain a high fluid resistance while using much larger fluid passages than standard Lee Jets. Thus, the protection screens can have larger openings, which are less susceptible to clogging than standard Lee Jets with the same lohm rating. Table 556-4-3 lists the original and new Lee part numbers and the National Stock Numbers (NSNs) of two Lee Visco Jets.

Table 556-4-3. LEE VISCO JETS FOR USE IN SUBMARINE HYDRAULIC SYSTEMS

Lee Visco Jet Part No.		Lohm Rating	National Stock Number
Original	New		
EX36441	VDCX0364410AF	30000	9C4730-00-883-7745
EX36442	VDCX0364420AE	24000	9C4730-00-269-4675

556-4.11.5 LEE JET SIZE MARKINGS. Two methods of marking Lee Jets have been used to identify the lohm rating. The original method used three marks on the band next to the outside filter screen consisting of two fine longitudinal marks next to each other, and a third single line at some angle, alpha (α) as shown in Figure 556-4-10. The number of lohms is determined from the formula $L = \alpha^2 /3$ where α is the included angle in degrees, clockwise from the double line, when viewing from the filter screen end, and L is the number of lohms. For example, if α = 90 degrees, L = (90 x 90)/3, or 8,100/3 = 2,700 lohms. On newer Lee Jets, the lohm ratio is electro-etched onto the body and is indicated by three digits and a multiplier. The tolerance is etched above the lohm rating. Lohm multipliers are L = 1, D = 10, H = 100, K = 1,000, and T = 10,000. In the example of Figure 556-4-10, the rating is 3,400 (340D = 340 x 10) lohms with a tolerance of ±5 percent. Refer to Table 556-4-2 for stock identification of available sizes.

556-4.11.6 INSTALLATION OF LEE JETS. The final Lee Jet restrictor sizes required in various systems are often arrived at by trial and error. This approach requires the repeated installation and removal of Lee Jet restrictors until the correct component speed is attained. Extra care must be exercised when installing or removing a Lee Jet restrictor from housings which use the expander pin to hold the Lee Jet (Figure 556-4-5 and Figure 556-4-7). Repeated or careless installation and removal of Lee Jets can result in degradation of the housing hole and the seat of the restrictor.

556-4.11.7 RESTRICTOR HOUSING USING EXPANDER PIN. To minimize damage and facilitate installation and removal of Lee Jet restrictors from restrictor housings having the expander pin, use a tool set equivalent to the Lee Jet Installation Extraction Tool Set shown in Figure 556-4-11. The tool set consists of two special bolts, called a body tool (8-36 UNF thread) and a pin tool (4-40 UNF thread), and a striker. The tool set is available under stock number NSN 9Q5180-00-980-3660 or directly from the Lee Company as Lee part number 187. After the correct size of Lee Jet has been determined, accomplish the permanent installation in accordance with the following procedures. First, insert the Lee Jet body into the hole and seat it to the shoulder (Figure 556-4-7). If the hole is deep, use the Lee body tool (Figure 556-4-11). Then drive the tapered expander pin into the Lee Jet body until the exposed ends (surfaces A and B on Figure 556-4-7) are flush with each other to within ±.005 inch. To remove a permanently installed Lee Jet, use the Lee pin tool and striker (Figure 556-4-11) to remove the Lee Jet Body.

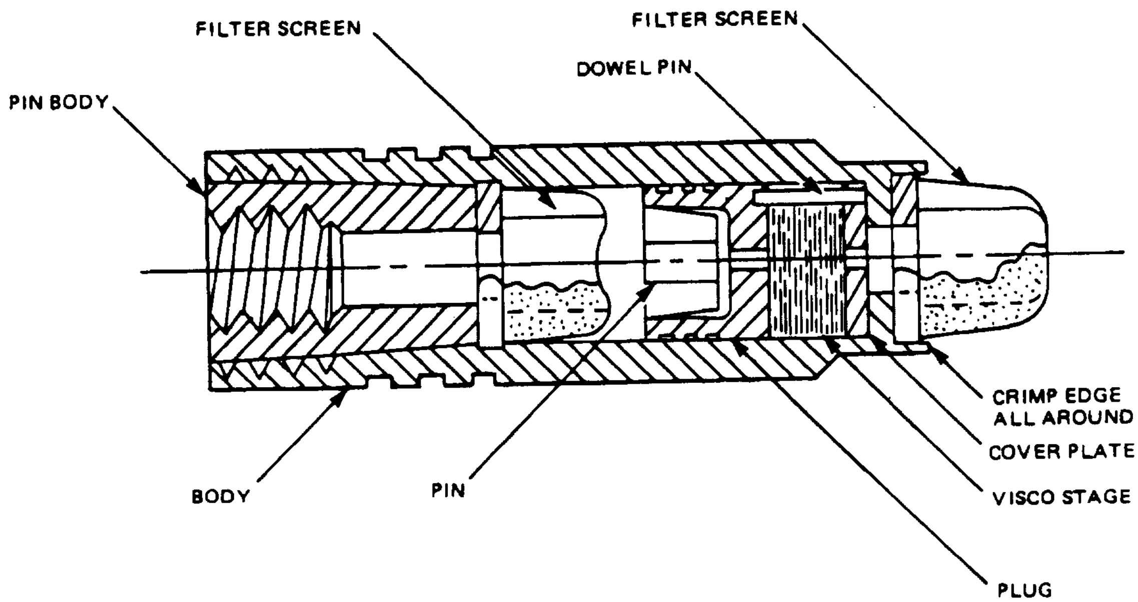


Figure 556-4-9. Lee Visco Jet

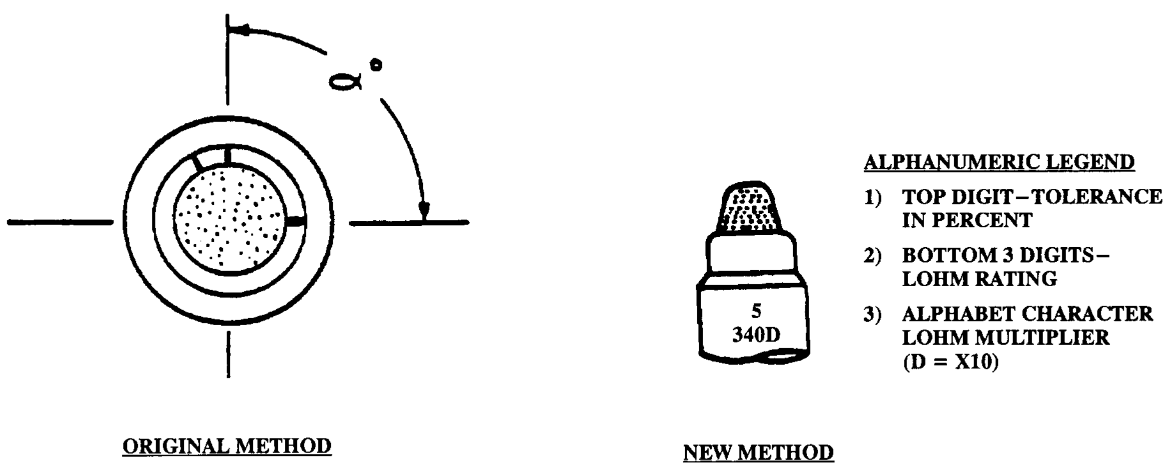


Figure 556-4-10. Lee Jet Marking

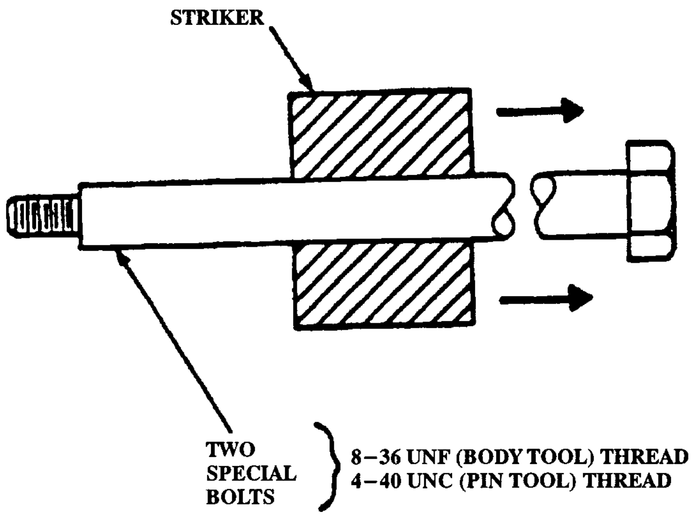


Figure 556-4-11. Lee Jet Installation/Extraction Tool Set

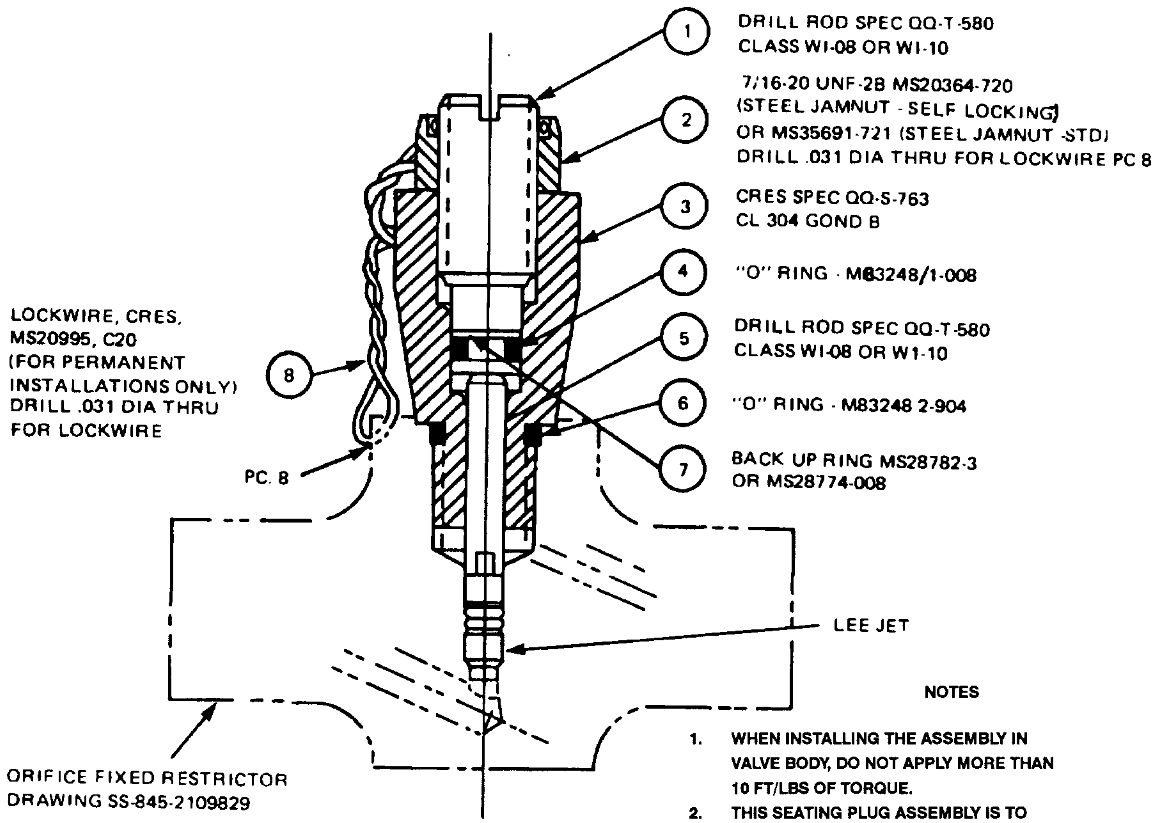
556-4.11.8 RESTRICTOR HOUSINGS WITHOUT EXPANDER PIN. For housings which do not use the expander pin to hold the Lee Jet (Figure 556-4-6) the following installation/extraction procedure is applicable (no special tools are required):

1. Remove cartridge from the housing body.
2. Remove retaining screw from cartridge.
3. Insert Lee Jet Body (Lee Jets are not to be expanded in the cartridge. Expander pin is to be discarded).
4. Replace retaining screw (use caution when tightening to prevent distortion of the Lee Jet).

556-4.11.9 TRIAL AND ERROR SIZING OF LEE JETS. To minimize the degradation of the hole and seat when sizing Lee Jet restrictors in housings using the expander pin, use a Lee Jet seating plug assembly (Figure 556-4-12). The assembly can be manufactured from the details provided in Figure 556-4-13. The following procedure applies for trial and error sizing of Lee Jet restrictors:

1. Insert the Lee Jet restrictor into its housing without the expander pin, holding the Lee Jet in place with the seating plug
2. Operate the component; change Lee Jet restrictors (expander pins are not to be used) as necessary until the desired speed is attained
3. When the Lee Jet size is found, remove the seating plug and install the expander pin in accordance with paragraph 556-4.11.7 for permanent Lee Jet installation.

Where degradation of the hole or seat of the Lee Jet housing has occurred, restrictor performance can sometimes be improved by permanently installing a Lee Jet seating plug. In this case the seating plug should be lockwired in place as shown in Figure 556-4-12. Another method to overcome degradation of the restrictor housing hole or seat is to use oversize Lee Deflector Jets. The oversize deflector jets are 0.197 inch in diameter versus 0.187 inch for standard deflector jets and are available from the Lee Company in the same lohm rating as standard jets. Replace housings that are excessively out of tolerance.



NOTES

1. WHEN INSTALLING THE ASSEMBLY IN VALVE BODY, DO NOT APPLY MORE THAN 10 FT/LBS OF TORQUE.
2. THIS SEATING PLUG ASSEMBLY IS TO BE USED IN LIEU OF EXPANDER PIN WHEN SIZING LEE JET RESTRICTORS.
3. FOR 0–RINGS, PC's 4 & 6, THE PREFERRED PRODUCTS ARE PER MIL–R–83248.
4. FOR DETAILS ON PC's 1, 3, & 5, SEE FIGURE Figure 556–4–13.

Figure 556-4-12. Lee Jet Seating Plug Assembly

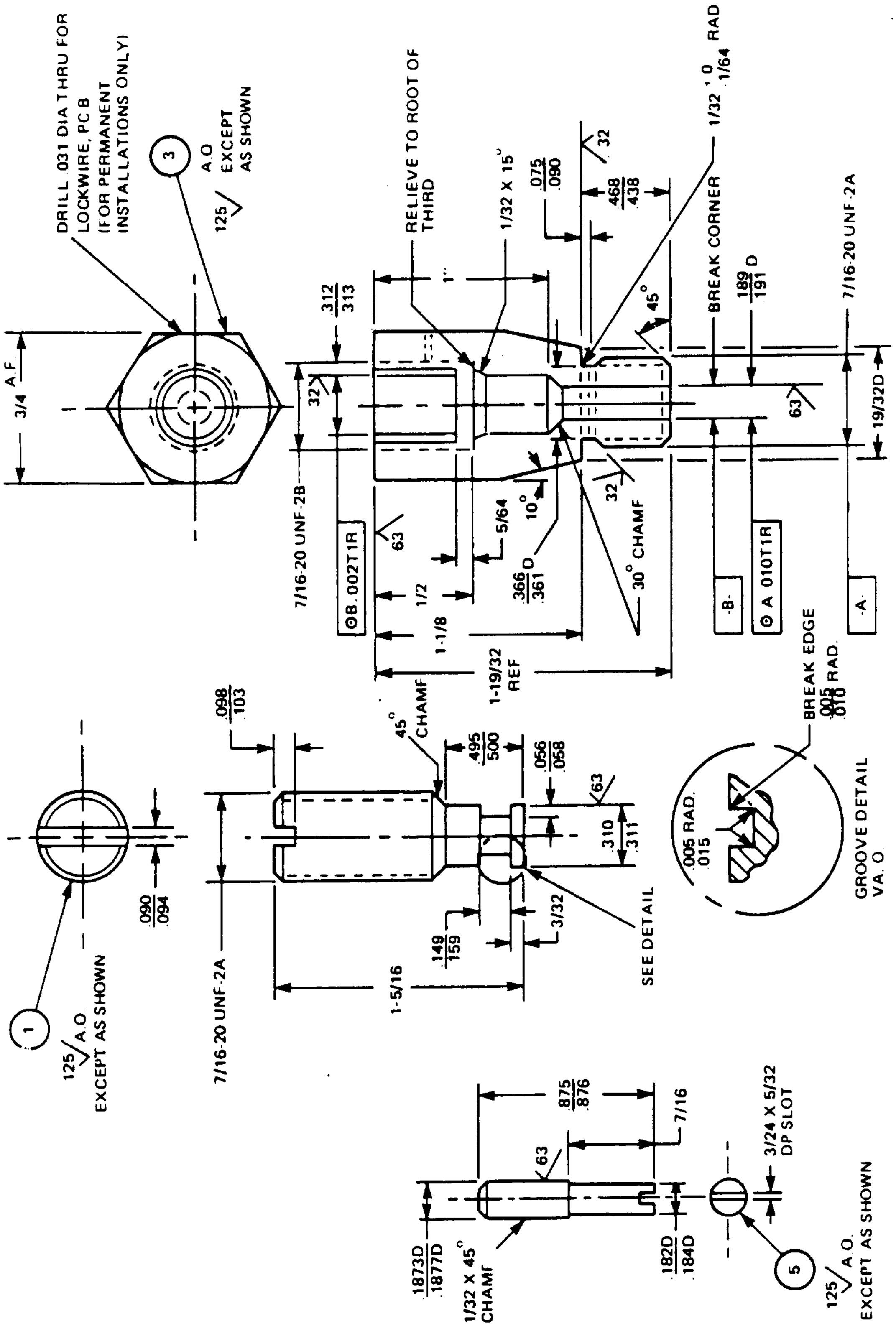


Figure 556-4-13. Machine Instructions for Lee Seating Plug Assembly

SECTION 5.
FLUIDS AND FLUID HANDLING

556-5.1 TYPES OF FLUIDS

556-5.1.1 GENERAL. Three general types of hydraulic fluids are used in shipboard applications. They are:

a. Petroleum base fluids

b. Synthetic fire resistant fluids

c. Water base fire resistant fluids

556-5.1.1.1 It is extremely important that the different types of hydraulic fluids are not intermixed in one system. If different type hydraulic fluids are mixed, the characteristics of the fluid required for a specific purpose are lost. Mixing the different types of fluids usually will result in a heavy, gummy deposit that will clog passages and necessitate a major cleaning chore. In addition seals and packing installed for use with one fluid usually are not compatible with the other fluids and damage to the seals will result. If it becomes necessary to change a system from one type of fluid to another, request instructions from NAVSEA.

556-5.1.2 PETROLEUM BASE FLUIDS. The most common hydraulic fluids encountered in naval shipboard systems are the petroleum based oils. For surface ships and the external hydraulic system of submarines, the fluid generally specified is a hydraulic fluid conforming to MIL-H-17672, (formerly MIL-L-15017). Three fluids of different viscosities are available under MIL-H-17672, identified by symbols 2075TH (lowest viscosity), 2110TH, and 2135TH (highest viscosity). Houghton PR 1192 is a water-emulsifyin g petroleum base fluid, with limited application in submarine hydraulic systems used to provide increased protection against rusting due to seawater contamination. For submarine hydraulic systems with screw type pumps, fluid conforming to MIL-L-17331 (2190 TEP) is generally specified for 3,000 lb/in^2 g systems while 2075TH is generally used for systems with pressures below 1,750 lb/in^2 . Other petroleum base fluids that are used in shipboard hydraulic systems include those conforming to MIL-F-17111 and MIL-H-83282. MIL-F-17111 is often used in ordnance systems and is suitable for use over wide temperature ranges because of its high viscosity index. The MIL-H-83282 is a synthetic hydrocarbon with some fire resistance used extensively in aircraft systems. Because of its low viscosity, it is often used for low temperature operation and in high performance craft such as hydrofoils to minimize system weight.

556-5.1.3 SYNTHETIC FIRE RESISTANT FLUIDS (PHOSPHATE ESTER BASE). Tertiary butylated triphenyl phosphate fluids per MIL-H-19457 have been used in aircraft elevators and other surface ship hydraulic systems where a fire resistant fluid is required. The current formulation, MIL-H-19457 Revision C and later is not toxic and less irritating than earlier formulations. The improved formulation is recognized by its blue color while the earlier formulations were green in color. Use only fluids in containers marked MIL-H-19457 Rev C, or later. Care is required in handling MIL-H-19457 fluid. Accordingly, warning signs should be placed in machinery spaces with hydraulic systems using this fluid and in stowage areas for these fluids. See paragraph 556-5.2 for handling precautions and protective equipment.

WARNING

Fluids used in this space require careful handling and good personal hygiene. Avoid Contact!
Do not eat, drink, or smoke in this space. Use protective clothing consistent with job requirements: consult work supervisor.
If contact is made: Wash skin thoroughly with soap and water. Flush eyes with water for 15 minutes. Remove soiled clothing and launder prior to reuse. Seek medical attention if fluid is swallowed, contacts eyes or if fluid vapor is inhaled.
In the event of a spill or spray, notify work supervisor or Medical or Safety Officer.

a. Lubricating properties, corrosion resistance, viscosity control, and stability of the MIL-H-19457 fluids have been demonstrated to be comparable to these properties in petroleum base fluids. While MIL-H-19457 fluids will burn with application of sufficient heat and pressure, they do not support combustion and are fire resistant in the use for which they are specified. Phosphate ester fluid will attack and loosen the commonly used paints and adhesives. Also, it will cause deterioration of many types of insulation used in electrical cables. Exteriors of hydraulic components containing phosphate ester fluids, and the ship structure and deck in the immediate vicinity of this equipment, should be coated with a two component epoxy paint in accordance with MIL-P-24441. See paragraph 556-11.2.1 and **NSTM Chapter 078, Seals** , for identification of compatible seal materials.

b. Because phosphate ester fluids are approximately 14 percent heavier than water for a given volume, water contamination rises to the top. Small amounts of water in the fluid may be driven off as vapors by the heat generated by operation of the equipment. Heavier concentrations of water should be drawn off by other methods or the contaminated fluid should be replaced. If a system must be flushed to remove heavy contamination it is recommended that a quantity of the phosphate ester fluid be used as the flushing agent. If contamination is extremely heavy it may be more economical to first use a hot water flush followed by complete drying with forced warm air and then a flush with the safety fluid.

556-5.1.4 SYNTHETIC FIRE RESISTANT FLUID (SILICONE). For hydraulic systems which require fire resistance, but have only marginal requirements for other chemical and physical properties common to hydraulic fluids, silicone fluids are frequently used. Silicones are generally poor in bulk modulus, lubricity, and corrosion protection, but excellent in fire resistance, and do not have the detrimental characteristics of phosphate ester fluid.

a. Silicone fluid MIL-S-81087, a chlorinated phenyl methyl polysiloxene, has been used in the missile holddown and lockout system in submarines. A Qualified Product List is available for the fluid.

b. Another silicone formulation, dimethyl polysiloxene, conforming to Federal Specification VV-D-1078 had been used previously in submarine missile systems. While both fluids are referred to as silicones, they are not the same and should not be mixed.

556-5.1.5 WATER-BASE FIRE RESISTANT FLUIDS. The broad term water-base fire resistant fluid may be applied to any one of a multiple of mixtures, many of which are not used in shipboard hydraulic systems. High water base fluids (approximately 95% water) have not been used in ship systems because the fluid would be subject to freezing in many applications and because of its low lubricity. Invert water-oil emulsions (approximately 40% water) have been considered for use but not yet installed in any systems. Two fluids which are used in shipboard applications are described below.

556-5.1.5.1 MIL-H-22072 Water-Glycol Fluid (NATO Code H-579). This fire resistant water base fluid is generally a water-glycol mixture containing 45 to 50% water. The fluid contains a red dye to improve visibility in liquid level gages and to aid in identification. Fire resistance of the water mixture depends upon the vaporization and smothering effect of the steam generated from the water. The water in water base fluids is slowly driven off as water vapor while the system is operating. Periodic checks of the water content and maintaining the correct percentage of water is important. To minimize water loss, fluid temperature should be maintained below 60°C (140°F). If the fluid temperature exceeds 80°C (176°F), the possibility exists that fluid dumping through a relief valve at high pressure could convert to steam. This fluid is used in aircraft handling machinery (catapults) and weapons elevators aboard aircraft carriers. It is usually the fluid of choice when a fire resistant fluid is required in shipboard applications. It should not be mixed with any other hydraulic fluid. As with any hydraulic fluid, care should be exercised in handling the fluid. Also, the warning signs as described in paragraph 556-5.2.1 are considered applicable for spaces containing hydraulic equipment using the fluid and in storage areas for the fluid. The following guidance applies to handling of this fluid.

a. Inhalation of high concentrations of vapors, mists or sprays may result in irritation of the respiratory tract. Breathing difficulty and pulmonary edema could also occur. Persons with chronic respiratory disease may show increased symptoms due to irritation.

b. Respiratory protection is not expected to be required under normal conditions. However, if mists or vapors are released to the work area as a result of gross spills or other causes, use a respirator. See paragraph 556-5.2.1 for protective equipment.

c. Avoid ingestion of the fluid. Food or tobacco products should neither be stored or consumed in areas where the fluid is stored or present. Always wash all exposed skin areas prior to consuming food or tobacco.

d. The fluid is a moderate eye irritant. Use protective eyewear (e.g. chemical worker's goggles or full face shield) when handling open containers of the fluid or when working in areas where eye contact is possible. (See warning in paragraph 556-5.1.3 in event eye contact occurs.)

e. Skin contact with the fluid may result in mild irritation. Use of impervious protective clothing, neoprene (or equivalent) is recommended. (See warning in paragraph 556-5.1.3 in event of skin contact.)

f. The manufacturer's Material Safety Data Sheet for each fluid used should be maintained near the work area and should be consulted for specific health and environmental control guidance.

g. Spill clean-up operations involving significant quantities should be performed by at least two persons.

556-5.1.5.2 MIL-H-5559 Arresting Gear Fluid. This is not a water base fluid in that it contains only 2.5 to 3 percent water. The fluid is 94 to 95% ethylene glycol with approximately 2.5% triethanolamine phosphate. This fluid should not be mixed with the MIL-H-22072 water glycol fluid because the percentage of water content and fluid properties are significantly different.

556-5.2 FLUID HANDLING PRECAUTIONS AND PROTECTIVE EQUIPMENT

556-5.2.1 HAZARDOUS MATERIALS. Hydraulic fluids are considered hazardous material. Safety guidance and personnel protective equipment for handling hydraulic fluids are identified in OPNAV P-45-10-91, **Hazardous Material Users Guide** . This guide should be available in every work center aboard ship.

556-5.2.2 MATERIALS FOR PROTECTIVE EQUIPMENT. **The Hazardous Materials Users Guide** referenced above lists National Stock Numbers for equipment which may be used in handling hydraulic fluids and other hazardous materials. When selecting protective clothing, such as gloves, consideration should be given to selecting materials that, when available, are compatible with the fluids to be handled. Listed below are fluids and compatible rubber materials:

a Petroleum based fluids: Nitrile, neoprene, flourocarbon

b. Water-glycol fluids: Almost all rubbers

c. MIL-H-19457 Phosphate ester fluids: Ethylene propylene, flourocarbon, butyl

The following butyl gloves are recommended for use with MIL-H-19457 fluids:

Size	**NSN**
Small	8415-00-820-6294
Medium	8415-00-820-6305
Large	8415-00-820-6293
Extra Large	8415-00-820-6292

556-5.3 FLUID AND SYSTEM CLEANLINESS

556-5.3.1 SYSTEM REQUIREMENTS. How frequently hydraulic fluid should be changed depends on the service, environment, fluid maintenance, equipment, and care. Because of the wide variation in these factors, no specific recommendations can be stated, because under optimum conditions a fluid will serve almost indefinitely.

NOTE

Refer to system and equipment manuals for more specific guidance.

556-5.3.1.1 Section 8 of this NSTM chapter provides allowable use limits for fluids, cleanliness requirements for submarine hydraulic systems, sampling procedures, and procedures for cleaning dirty systems.

556-5.3.2 CLEANLINESS OF NEW FLUIDS. New fluid procured to military specifications must meet the specification requirements in regard to the amount of particulate and water contamination allowed. In general, fluids are being procured in as clean a condition as possible because of economic and practical limitations. Unless purchased to very stringent cleanliness requirements and packaged in clean, hermetically sealed containers, the fluid received at the end-use point may not meet cleanliness requirements for the hydraulic system in which it will be used. In most cases, filtering the fluid at the end-use point is more economical and effective than to procure superclean fluid in small hermetically sealed cans.

556-5.4 FLUID STORAGE AND HANDLING

556-5.4.1 STORAGE AND HANDLING REQUIREMENTS. Storage and handling guidance for fluids is provided in MIL-HDBK 200, **Quality Surveillance Handbook for Fuels, Lubricants, and Related Products** . Some of the factors which result in fluid contamination during handling and storage are:

a. Residual dirt in drums before filling

b. Dirt generated in drums from handling and banging around

c. Water contamination of drums from improper outdoor storage with the bungs up

d. Corrosion of drums or decay of drum coatings from adverse storage conditions, such as moisture, extreme temperatures, and long term storage

e. Contaminated holding tanks on tankers and tenders

f. Leaving transfer hoses uncapped

g. Using transfer hoses for other purposes, and not flushing contaminated hoses before use

h. Normal degradation of hose materials from exposure and aging

i. Loading fluid during rainstorms without adequately sheltering the drum or system fill opening

j. Not issuing old stock first

k. Not analyzing samples of old stock

NOTE

Drums of fluid that have been stored outdoors, unsheltered with the bungs up, should not be used until analyses can be performed to confirm the absence of water contamination (see paragraphs 556-8.3.4 and 556-8.5.1). If water has ever accumulated on the top of these drums, the fluid is almost certain to be contaminated.

556-5.4.2 QUALITY CONTROL ANALYSIS. Requirements of quality surveillance of bulk and packaged fuels, lubricants, and related products are contained in **Quality Surveillance Handbook for Fuels and Lubricants** , MIL-HDBK-200. For all types of hydraulic fluids in storage, a visual check is required every 12 months, and tests are required every 2 or 3 years or whenever stocks are suspected of not meeting the specification. The type of tests performed is left to the discretion of the Inspection Authority, who considers the type of product, age of stock, and conditions of storage.

556-5.4.2.1 Types of Tests. The types of tests in MIL-HDBK-200 are:

a. Type A Test - Complete specification acceptance test.

b. Type B-1 Test - Partial testing of principal characteristics most likely to be affected in transfer of the product.

c. Type B-2 Test - Partial testing of critical characteristics that are susceptible to deterioration because of age.

d. Type B-3 Test - Partial testing of product to be performed when contamination is suspected.

e. Type C Test - Quick, simple, partial testing for verification of product quality.

556-5.4.2.2 Type B-2 Tests for Hydraulic and Lubricating Fluids. Type B-2 tests include visual checks yearly and retests every 24 or 36 months, depending on the fluid. For most hydraulic fluids the minimum frequency of retesting is 24 months although the minimum frequency for MIL-H-17672 fluids (2075TH, 2110TH, and 2135TH) is 36 months. As a minimum, properties subject to B-2 hydraulic fluid testing usually include appearance, viscosity determination, water content, solids or sediment content, and emulsification. Neutralization numbers, pour point, and flash point are other tests often required.

556-5.4.3 CONTAINER MARKING. The markings required on most lubricating and hydraulic fluid containers are identified by specification references to **Packing of Petroleum and Related Products** , MIL-STD 290. Most ship hydraulic fluid containers have the following marking requirements:

a. Military Symbol

b. Specification Number

c. Stock Number

d. Manufacturer's Name

e. Contract Number

f. Batch Number and Date of Manufacture

g. Qualification Number.

556-5.4.3.1 When used drums are refilled with good fluid, all old drum markings shall be obliterated, the drums thoroughly cleaned, and the drums marked as described in **Quality Surveillance Handbook for Fuels and Lubricants** , MIL-HDBK 200. When empty drums or other containers are used to hold contaminated fluids or waste oils, all original markings shall be obliterated. New markings shall be added to the containers stating **Warning, Contains Waste (Identify Fluid) Fluid, Do Not Load Into Ship Systems** .

556-5.5 LOADING FLUID INTO THE SYSTEM

556-5.5.1 LOGGING FLUID IDENTIFICATION DATA Knowing the quantity and positive identification of a fluid will minimize fluid problems and can facilitate corrective action when problems occur. Specific identification information, whenever available, shall be recorded in the ship fuel and water log (or equivalent log) whenever fluid is added to the system. The date and amount of fluid added, along with the container markings listed in paragraph 556-5.4.3, shall be logged. Activities that elect to remove the oil from the ship and to clean, test, and reload the used oil in the same ship or another ship shall log the testing data (see paragraph 556-5.6.6) as well as the number of the hull from which the oil was obtained.

556-5.5.2 VERIFICATION OF FLUID ACCEPTABILITY. Before loading any fluid into a reserve tank or hydraulic system:

1. Visually observe the drum markings to verify that the proper fluid will be installed. Check every drum if more than one is being loaded.

2. Check for fill dates and inspection dates to make sure the fluid has been inspected within required time limit (see paragraphs 556-5.4.2 through 556-5.4.2.2). Do not load fluid until test and visual inspections required by MIL-HDBK 200 have been accomplished.

3. If drum cap seals or other container seals have been broken, or if drums have been stored outdoors unsheltered with the bungs up, it will be necessary to visually inspect the fluid before loading. Detailed sampling guidance is provided in MIL-HDBK 200. As a minimum the following requirements shall be met:

   a Roll drums before sampling to stir up contaminants.

   b If possible, draw the sample from the lower portion of the drum.

NOTE

> Oil with a cloudy appearance or water droplets is justification for rejection of the drum.

c Visually check each drum suspected of being contaminated with water.

d Place tags on all water contaminated drums so no one uses them.

4. For bulk fluids, one or two representative samples (such as from a discharge connection or drain line) should be visually checked for the presence of water. A clear and bright sample is acceptable. Bulk fluid is provided in large quantities (compared to 55-gallon drums) and representative samples may be difficult to obtain. Additional samples and even laboratory analysis may be required if reasonable doubt exists about the quality of the fluid.

5. The sampling and analysis of fluids, solely for the purpose of identifying solid contaminants, is not required if the fluid will be filtered before being added to the system. For example, it is known that fluid from drums often will not meet cleanliness requirements imposed on submarine hydraulic systems. Filtering fluid is considered to be more economical that particulate analysis of the fluid.

556-5.5.3 LOADING REQUIREMENTS AND EQUIPMENT. Requirements that apply to loading fluid into hydraulic systems are:

a. Hydraulic fluids, in accordance with MIL-H-5606, MIL-H-6083, MIL-H-46170, and MIL-H-83282, contain particle contamination limits which are so low that the product is packaged under clean-room conditions. Prior to opening the container, rinse with filtered solvent the opener and the area to be opened. The fluid may be added directly to the system without filtering.

b. Verify fluid acceptability prior to loading (see paragraph 556-5.5.2).

c. Do not attempt to remove water from a contaminated fluid during loading. The high temperature and low viscosity generally needed for effective water removal are difficult to obtain in a single pass loading operation, and removal of water to required limits is doubtful. If water-contaminated fluid must be used, remove the water prior to loading.

d. Do not load fluid in the rain unless shelter is provided for the drain and system fill connection so that no water will get into the system.

e. Filter all fluid being added to the system from drums or bulk fluid storage tanks (see paragraph 556-5.5.3.1 for filtering equipment).

NOTE

> Frequently, as with most submarine hydraulic systems, the filtration step can be accomplished by using system filters which are installed between reserve tanks and the hydraulic system reservoir (vent and supply tanks in submarines). Filtering the fluid added to these reserve tanks is not mandatory, but is considered to be a good practice.

f. All containers, pumps, hoses, and other equipment used in loading oil must be clean. Hoses and open fittings must be capped when not in use. Pumps, filters, and related equipment used to transfer hydraulic fluid into the ship shall not be used for other purposes (such as handling other incompatible oils, fuels, water, or contaminated fluids). MIL-L-17331 and MIL-H-17672 fluids are compatible, and for purposes of loading, any traces of either fluid remaining in pumps and hoses will not be sufficient to affect the properties of the other. Any of these fluids can be loaded into the appropriate system without fear of contaminating the transfer equipment.

556-5.5.3.1 Filtering Fluid During Loading. Filters used when loading fluid should provide filtration at least as effective as filters installed in the system to which the fluid is added. The filters should be of the nonbypass type to prevent loading contaminated fluid once the filter element is loaded with contaminants. Specific recommendations for filter elements and filtering rigs are made in paragraphs 556-5.5.3.2 through 556-5.5.3.4.

NOTE

General information on filtration equipment is provided in Section 7 of this NSTM chapter.

556-5.5.3.2 Filter Elements. Filter elements should have as a minimum an absolute rating of 25 micrometers or a nominal rating of 10 micrometers. Filter elements conforming to MIL-F-8815 or MIL-F-24402 are not often economical for these low pressure cleanup operations; however, MIL-F-24702 and MIL-F-24702/1 filter elements will provide inexpensive but effective filtration.

556-5.5.3.3 Filtering Rigs. Filtration for transfer of fluid normally can be provided by a portable filtration cart that is equipped with high efficiency, high capacity elements capable of removing solid particulate and water contaminants quickly. Commercial Item description (CID) A-A-50455 presently covers 10 gal/min (38 liters/min), 16 gal/min (60 liter/min), and 25 gal/min (95 liter/min) rated flow capacity filtration carts. These carts are identical in overall dimensions and accept the particulate removal filter elements that are in conformance with MIL-F-24702 and MIL-F-24702/1. For water removal, the filter housing accepts the filter elements that conform to the dimensions specified in MIL-F-24702/1. These carts provide dual filtration with both particulate and water contaminant removal as they are equipped with two primary pressure filters connected in series. This double bowl configuration thus provides a flexibility of capturing larger particulates through the first stage (inlet) filter and the finer particulates or water through the second stage (outlet) filter. The carts are also equipped with a tri-color dirt alarm indicating when elements need replacing, and quick-disconnects to facilitate hookup at inlet and outlet ports. The electric power requirement is 115 volts for the 10 and 16 gal/min flow rate carts and 440 volts for the 25 gal/min flow rate cart. The dry weight for the 10 gal/min flow rate cart is 140 pounds (64 kilograms), 155 pounds (70 kilograms) for 16 gal/min flow rate cart, and 170 pounds (77 kilograms) for 25 gal/min flow rate cart.

a. A 16 gal/min rated flow capacity cart is currently stocked under National Stock Number (NSN) 4330-01-044-7992 at reasonable cost. This unit with two filter elements and a pumping capacity of 16 gal/min (60 liters/min) should clean at least five drums of MIL-L-17331 (2190-TEP) fluid (more drums of less viscous fluid) before a change of elements is required. The principal supplier of the 16 gal/min flow cart is Schroeder Industries. Older Schroeder Filter Carts, Model HFB-2K3-1.5 are not compatible with phosphate ester base fluid (MIL-H-19457) unless a conversion kit is installed. The conversion kit, Schroeder P/N ALF-2276 is available from Schroeder Industries, Box 72, McKees Rocks, PA 15136; (412) 771-4810. Filter Cart, Model HFB-2K3-2KW-1.5G1081, as currently supplied, is compatible with MIL-H-19457 phosphate ester base as well as petroleum base fluids, and no conversion kit is required. National Stock Numbers (NSN's) for the 10 and 25 gal/min rated flow capacity carts are 4330-01-359-1781 and 4330-01-358-7078 respectively.

b. The filter carts utilize non-cleanable, Beta10 elements (NSN 4330-00-229-4157) that provide a filtration ratio of 75 (efficiency of 98.7%) for particles larger than 10 micrometres. (See paragraph 556-7.4.1.1 for an explanation of Beta ratios.) These elements utilize fluorocarbon rubber O-ring seals compatible with all shipboard hydraulic fluids.

556-5.5.3.4 Avoiding Fluid Aeration. Hydraulic fluid should be added to a system as far in advance of system use as possible. The pouring of fluid into a reservoir stirs up contamination already present and the attendant turbulence aerates the fluid. Letting the fluid stand undisturbed for a time allows heavier particles of contamination to settle and air to escape.

CAUTION

Excessive foaming or entrainment of air in the fluid causes a spongy system, reduces heat absorption and heat radiation capacity, induces cavitation, speeds fluid oxidation, and has other undesirable effects.

556-5.6 FLUID VISCOSITY

556-5.6.1 VISCOSITY REQUIREMENTS. The viscosity requirements for various fluids used in ship hydraulic systems are contained Table 556-5-1 and Figure 556-5-1. Minimum recommended viscosity use limits for various fluids are identified in Table 556-8-1. See paragraph 556-5.6.7 for viscosity measurement guidance.

Table 556-5-1. VISCOSITIES OF VARIOUS HYDRAULIC FLUIDS USED IN SHIPS

Fluid Symbol or Designation	Military Specification	ISO Viscosity Grade	Kinematic Viscosity Range in Centistokes at 40°C (104°F)
NATO H-575	MIL-F-17111	--	Not specified (Approx 27 to 30)
2075TH	MIL-H-17672C	--	23.5 to 30.0
	MIL-H-17672C Amendment No. 1 and later	32	28.8 TO 35.2
2110TH	MIL-H-17672C	--	36.5 to 40.0
NATO Symbol H-573	MIL-H-17672C Amendment No. 1 and later	46	41.4 to 50.6
2135TH	MIL-H-17672C	--	50.5 to 63.0
	MIL-H-17672C Amendment No. 1 and later	68	61.2 to 74.8
2190 TEP NATO Symbol 0-250	MIL-L-17331G Amendment No. 1	--	74 to 97
Triaryl Phosphate Ester NATO Symbol H-580	MIL-H-19457	--	38.5 to 45.5
Water-glycol	MIL-H-22072	--	Not specified (Approx 36 to 43)

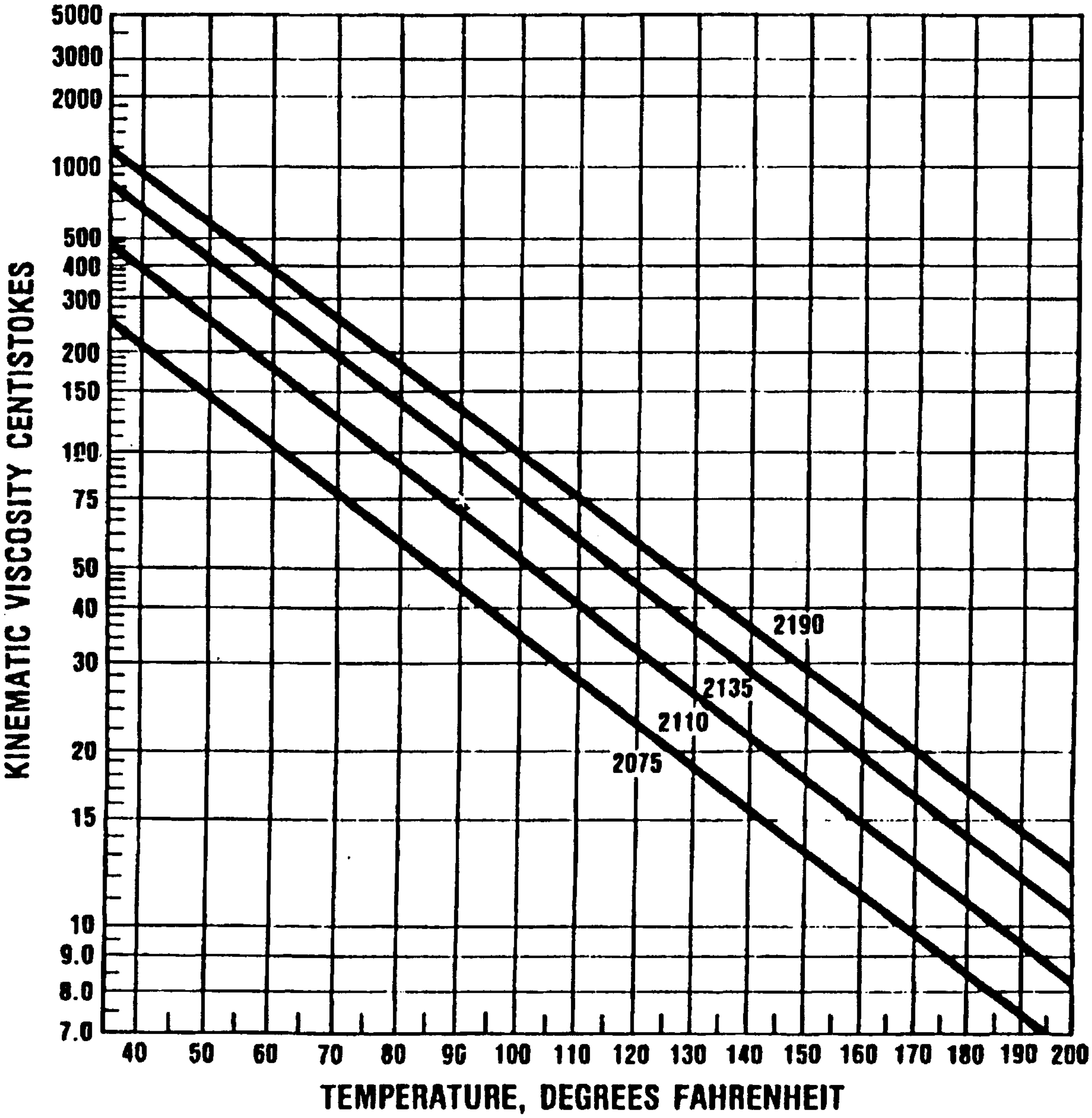


Figure 556-5-1. Viscosity-Temperature Chart for MIL-L-17331 and MIL-H-17672 Petroleum Base Hydraulic Fuids

556-5.6.2 MIL-H-17672 FLUID VISCOSITY. As indicated in Table 556-5-1 the viscosity requirements for 2075TH, 2110TH, and 2135TH fluids per MIL-H-17672C were changed by amendment No. 1 to the specification. The change was made to allow use of ISO viscosity grade fluids that are more apt to be commercially available. As a result, fluids conforming to Revision C, Amendment No. 1 and later, will be more viscous. If the increased viscosity results in operational problems, notify NAVSEA so that a change to fluid with a lower viscosity may be investigated.

556-5.6.3 CHANGE OF FLUID VISCOSITY GRADE FOR SUBMARINE HYDRAULIC SYSTEMS. With the change in viscosity of MIL-H-17672 fluids, the fluid changes identified below are recommended for submarine hydraulic systems.

556-5.6.4 EXTERNAL HYDRAULIC SYSTEMS. For external hydraulic systems that use MIL-H-17672 fluids, the fluid preferred for use is now 2075TH. This fluid (either old or new viscosity) may be added, as replenishment is necessary, to systems containing 2110TH fluid.

556-5.6.5 MAIN-VITAL AND INTERNAL SYSTEMS. For internal systems under 1,650 lb/in^2 operating pressure, the new 2075TH viscosity Grade 32 fluid per MIL-H-17672C, Amendment No. 1, may be added (as replenishment is necessary) to systems using 2110TH fluid. However, substitution of older viscosity grade 2075TH fluid (MIL-H-17672 Revision C and earlier) for 2110TH is not recommended except under emergency conditions. The specification revision and amendment applicable (or through which the fluid was procured) should be marked on the drum.

556-5.6.6 CONTINUED USE OF MIL-L-17331 OIL IN SUBMARINE HYDRAULIC SYSTEMS. Oil per MIL-L-17331 that is or has been in service in submarine 3,000-lb/in^2 hydraulic systems is considered satisfactory for continued service (only in those systems) if specific test criteria are met. Criteria testing of shipboard oils is normally conducted during scheduled overhauls. The addition of used MIL-L-17331 oils to previously tested oils prior to loading is cause for retesting. To be acceptable for continued service in 3,000-lb/in^2 hydraulic systems, MIL-L-17331 oil shall conform to the following criteria:

1. Water, per American Society for Testing and Materials (ASTM) method D1744, shall not exceed 0.05 percent by volume. Excessive water may be removed from the oil to meet this requirement.
2. Particulates shall meet the appropriate overhaul limits per Table 556-8-4. Excessive particulates may be removed from the oil to meet this requirement.

NOTE

Water and particulate contaminants shall be at acceptable levels before the remaining tests are performed.

3. Flash point, per ASTM method D92, shall not be less than 204°C (400°F).
4. Viscosity, per ASTM method D445, shall be between 70 and 97 centistokes at 40°C (104°F).
5. Acidity (neutralization number), per ASTM method D974, shall not exceed 0.5 percent.
6. Oxidation by rotating bomb (RBOT), per ASTM method D2272, shall not take fewer than 75 minutes.

556-5.6.7 VISCOSITY MEASUREMENTS. It is recommended that fluid in systems which operate almost daily be checked for viscosity semi-annually. Fluid in systems which operate less frequently should be checked annually. Minimum viscosity requirements are identified for various fluids in Table 556-8-1. The fluids may be forwarded to a laboratory following the guidance in paragraphs 556-8.4.5 and 556-8.4.6 if the ship does not have analysis capability. Many fluids can be checked for viscosity on the spot using the viscosity comparator described in paragraph 556-5.6.7.1.

556-5.6.7.1 Viscosity Comparator. The viscosity comparator is a pocket instrument which is used to make quick oil viscosity measurements at room temperatures. It is convenient to use and normally does not require either a thermometer or stop watch. The Visgage Model 2 comparator (NSN 6630-00-255-8057) is currently used for lubricating oils on many ships and has a scale range from 0 to 2000 Saybolt Universal Seconds (SUS) and indicates the viscosity at 100°F (38°C). The Visgage Model 38 comparator has a scale range of 0 to 400 centistokes and indicates the viscosity at 40°C (104°F). Action is being initiated to establish a NSN for this preferred instrument.

The following formulae can be used to convert SUS times in seconds (t) to centistokes (cSt):

$cSt = 0.266t - (195/t)$ where t is between 32 and 100

$cSt = 0.220t - (135/t)$ where t is greater than 100

The following limitations apply when using the comparators to measure viscosity:

a. Follow manufacturer's directions for the instrument.

b. These instruments are recommended only for petroleum base fluids.

c. The instruments contain oil with a 95 viscosity index and therefore will work best when the fluid being measured has a similar viscosity index. Accordingly, the comparators should work well with MIL-H-17672 and MIL-L-17331 fluids.

d. Since MIL-H-5606, MIL-F-17111 and MIL-H-83282 fluids have a higher viscosity index, accuracy can be obtained only if the instrument and the oil are warmed to 100°F (38°C) for the Model 2 and to 40°C (104°F) for the Model 38.

556-5.6.8 FLUID DISPOSAL. Used fluids must be stored for shore disposal. See **NSTM Chapter 670, Stowage, Handling and Disposal of Hazardous General Use Consumables** , and **NSTM Chapter 593, Pollution Control** , for additional guidance.

SECTION 6.

RESERVOIRS, HEAT EXCHANGERS, AND ACCUMULATORS

556-6.1 RESERVOIRS

556-6.1.1 Any hydraulic system must have a reserve of fluid in addition to that contained in the pumps, actuators, pipes, and other components of the system. This reserve fluid must be readily available for making up losses of fluid from the system, to make up for compression of fluid under pressure and to compensate for the loss of volume as fluids cool. This extra fluid is contained in a tank generally called a reservoir.

a. Sump tank, service tank, operating tank, supply tank, and base tank are other names sometimes applied to the reservoir.

b. In addition to providing storage for the reserve of fluid needed for the system, the reservoir acts as a radiator for dissipating heat from the fluid and as a settling tank where heavy particles of contamination may settle out of the fluid and lie harmlessly on the bottom until removed by cleaning or flushing the reservoir. Also, it allows entrained air to work out of the fluid. Most reservoirs will have a capped opening for filling, an air vent, an oil level indicator or dip stick, a return line connection, a pump inlet or suction line connection, drain line connection, and a drain plug. The inside of the reservoir generally will have baffles to prevent excessive sloshing of the fluid and to put a partition between the fluid return line and the pump suction or inlet line. This partition serves to force the returning fluid to travel farther around the tank before being drawn back into the active system through the pump inlet line.

c. The size and configuration of a fluid reservoir and the recommended operating fluid level in the tank generally are determined by the special requirements for the system. Before starting each equipment, the operator should ensure that the reservoir is filled to the recommended level with the correct fluid. Operating with the fluid level below recommended level increases the probability of:

1 Running out of fluid to make up losses.

2 Aerating the fluid due to excessive turbulence.

3 Excessive buildup of heat in the fluid.

4 Stirring up contamination from the bottom.

5 Additional water contamination from the larger air volume.

6 Fluid return lines being exposed, with resultant spewing of returning fluid onto the surface of the fluid in the reservoir, thereby inducing foaming and aeration.

d. Most reservoirs, are fabricated from steel and may or may not be coated. Reservoirs for synthetic fluids are not usually coated. Coatings conforming to MIL-P-24441 and MIL-P-23236 classes 1 and 4 are compatible with both phosphate ester and petroleum base fluids and with each other, and may be applied, over interior surfaces prepared by abrasive blasting, to new reservoirs where coatings are permitted. When a reservoir is opened to inspect the suction strainer (see paragraph 556-7.3.2) the condition of the coating should be observed. Any loose or deteriorated coating should be removed by abrasive blasting or disc sanding and the surfaces degreased prior to recoating the entire surface with one of the above specification coatings applied in accordance with applicable procedures. Guidance on surface preparation and coating is provided in **NSTM Chapter 631, Preservation of Ships in Service** . Reservoirs of stainless steel construction or with stainless steel liners should not be coated. Any such reservoirs which previously may have been coated should not be recoated but should have any flaking or loose coating removed. Any coating strongly adhering to the stainless steel may be left undisturbed. Application of coatings to internal tank surfaces is not recommended for accomplishment by forces afloat.

556-6.2 HEAT EXCHANGERS

556-6.2.1 GENERAL. Heat will cause hydraulic fluid to become less viscous and when it becomes too thin both internal and external leakage will increase. Leakage within the pumps and other components causes inefficiency and still greater heat generation. Heat also causes seals and packings to deteriorate more rapidly. Fluid which is heated excessively breaks down and loses its lubricity and other special features. Hydraulic systems with adequate radiating surfaces to dissipate heat, large reservoirs, long lead of pipes, and so forth, will generally operate at acceptable temperature levels. Some systems, however, must have a heat exchanger to reduce the fluid temperature. The two basic types of heat exchangers found on Navy shipboard equipment are the fluid-to-water exchanger and the fluid-to-air exchanger.

556-6.2.2 FLUID-TO-WATER TYPE. The fluid-to-water heat exchanger generally has a cylindrical body in which numerous small tubes run from one end to the other. The tubes terminate in a header plate at each end of the exchanger body. End caps are installed to form a chamber at each end. Cooling water is forced through the tubes and the hydraulic fluid flows around the outside of the water tubes within the exchanger body. Heat from the hydraulic fluid transfers to the cooling water.

a. There are numerous variations of this type exchanger, such as coolers with two or more passes of water through the tubes and coolers with double-walled tubes to provide greater protection from leakage of one fluid into the other. Where double-walled tubes are used, the drain-off of the void space should be monitored continuously.

b. The fluid-to-water cooler must have a supply of cooling water and there is always the danger that water may get into the hydraulic fluid. However, these coolers are highly efficient and a small size unit is capable of extracting a large amount of heat from the hydraulic fluid.

c. A fluid-to-water cooler may lose efficiency because the tubes are plugged or coated with deposits. If the fluid temperature cannot be held to an acceptable level, this may be the cause. The end caps should then be removed and the tubes cleaned. If it is suspected that heavy deposits have accumulated on the oil side of the tubes, the exchanger should be thoroughly back-flushed or chemically cleaned. (See **NSTM Chapter 220, Boiler Water/ Feedwater** for procedure.) After cleaning a cooler, it should be tested for leaks by pressurizing the hydraulic fluid side with a charge of fluid, or with air, and noting any losses. The system fluid should be continuously monitored for signs of water. If water is noted in the hydraulic fluid the heat exchanger should be tested for leaks. Similarly, if hydraulic fluid is being lost from the system, and there are no visible leaks in other places, the heat exchanger should be tested to ensure that the hydraulic fluid is not getting into the cooling water.

d. Most systems having hydraulic fluid-to-water heat exchangers have some means to control the flow of water through the cooler. Generally, it is desirable to keep the hydraulic fluid temperature to a minimum of 40°C (104°F), therefore, the water flow should be regulated to prevent excessive cooling. If automatic regulating equipment is installed it should be checked regularly.

556-6.2.3 FLUID-TO-AIR TYPE. In some applications, particularly on weather decks, it may be more desirable to use a fluid-to-air heat exchanger.

a. This type cooler does not require the plumbing of a fluid-to-water cooler and will not contaminate the hydraulic fluid with water if a leak occurs. The fluid-to-air-heat exchanger passes the fluid through small finned tubes or through some type of multiple passage radiator core. Air is generally blown over the cooling unit with a fan. The warm air from the cooler makes this type undesirable for many installations, particularly inside the ship.

b. Maintenance of fluid-to-air heat exchangers consists mainly of keeping the radiating surface free from dirt and debris. If excessive pressure drop across the heat exchanger indicates that the fluid flow is restricted, the unit may need to be flushed or, in severe cases, disassembled and cleaned. If the fins of the fluid carrying tubes are bent or damaged they should be straightened or repaired.

556-6.3 ACCUMULATORS

556-6.3.1 GENERAL. An accumulator is a pressure storage reservoir in which hydraulic fluid is stored under pressure from an external source, usually a pump. Accumulators are used for:

a. Hydraulic shock suppression

b. Fluid make-up in a closed system

c. Leakage compensation

d. Emergency power in case of loss of normal power

e. Holding high pressure without keeping pump in continuous operation

556-6.3.1.1 The types of accumulators encountered in shipboard system are:

a. Piston type

b. Bag or bladder type

c. Direct contact gas over hydraulic fluid type

556-6.3.2 PISTON TYPE ACCUMULATORS. Piston type accumulators are used on submarines and surface ships. They consist of a cylindrical body called a barrel, closures on each end called heads, and an internal piston. The piston may be fitted with a tailrod which extends through one end of the cylinder, as shown in Figure 556-6-1, or may not have a tailrod at all, and is usually referred to as a floating piston. Hydraulic fluid is pumped into one end of the cylinder and the piston is forced toward the opposite end of the cylinder against a captive charge of air or an inert gas such as nitrogen. Sometimes the amount of air charge is limited to the volume within the accumulator; other installations may use separate air flasks which are piped to the air side of the accumulator. Piston accumulators may be mounted in any position, but the preferred orientation is with the axis vertical. This position eliminates side loading on the piston and rod seals and minimizes scoring of the barrel and tailrod. The gas portion of the accumulator may be located on either side of the piston. For example, in submarine hydraulic systems with tailrod pistons, the gas is usually on the bottom and the fluid on top; in surface ships with floating pistons the gas is often on the top. The orientation of the accumulator and determination of the type of accumulator has been based upon such criteria as available space, maintenance accessibility, size, need for external monitoring of piston location (tailrod indication) contamination tolerance, seal life, and safety. The purpose of the piston and the piston seals is to keep the fluid and the gas separate. Because these seals will allow some oil into the air side due to normal wiping action and eventual seal wear, it is good practice to periodically drain off the air side of the accumulator or associated air flask. Unless otherwise specified, monthly is considered a reasonable period for this check. Usually tailrod accumulators utilize two piston seals, one for the air side and one for the oil side, with the space between them vented to atmosphere through a hole drilled the length of the tailrod. When piston seals fail in this type of accumulator, air or oil leakage is apparent. However, seal failure in the floating piston or non-vented tailrod accumulators will not be as obvious. Therefore, more frequent attention to venting or draining the air side is necessary. An indication of worn and leaking seals can be detected by the presence of significant amounts of oil in the air side. For these installations, venting the air side as frequently as once a day is recommended.

556-6.3.3 PISTON TAILROD TYPE ACCUMULATOR MAINTENANCE. The information presented in the following paragraphs is directed specifically to the maintenance and overhaul of submarine hydraulic system piston tailrod type hydraulic accumulators. However, much of the guidance on disassembly and reassembly procedures will be useful in the repair of other shipboard accumulators. Figure 556-6-1 shows a cross-sectioned view of a typical piston tailrod type hydraulic accumulator, and Figure 556-6-2 shows an exploded view of the same. Dynamic seals failure criteria (maximum allowable leakage) is applicable only to submarine hydraulic power plant accumulators. Allowable leakage criteria for flood control accumulators is currently specified in applicable Unrestricted Operations-Maintenance Requirement Cards (URO-MRCs). The primary areas of concern related to hydraulic accumulator maintenance are timeliness and technique. In many instances hydraulic accumulator dynamic seals (piston seals and the tailrod seal) are replaced prematurely. Each seal replacement action, because of the size, weight, crowded working conditions, and the generally cumbersome nature of the assembly, exposes the critical surfaces of the accumulator to damage. Apparent minor damage, such as small nicks and scratches on the tailrod and the cylinder internal surface will severely reduce dynamic seal life. For these reasons, seals should not be replaced until absolutely necessary. As to technique, the use of proper tools, simple precautions, and patience during disassembly and reassembly will significantly reduce the possibility of physical damage to the accumulator components (nicked tailrods, cut seals) and ensure a successful maintenance action. Haste during certain critical reassembly steps can easily result in cut or nibbled dynamic seals and backup rings. This damage will not be discovered until the accumulator is aligned for operation or shortly thereafter. Excessive leakage will quickly develop and the maintenance action will have to be repeated.

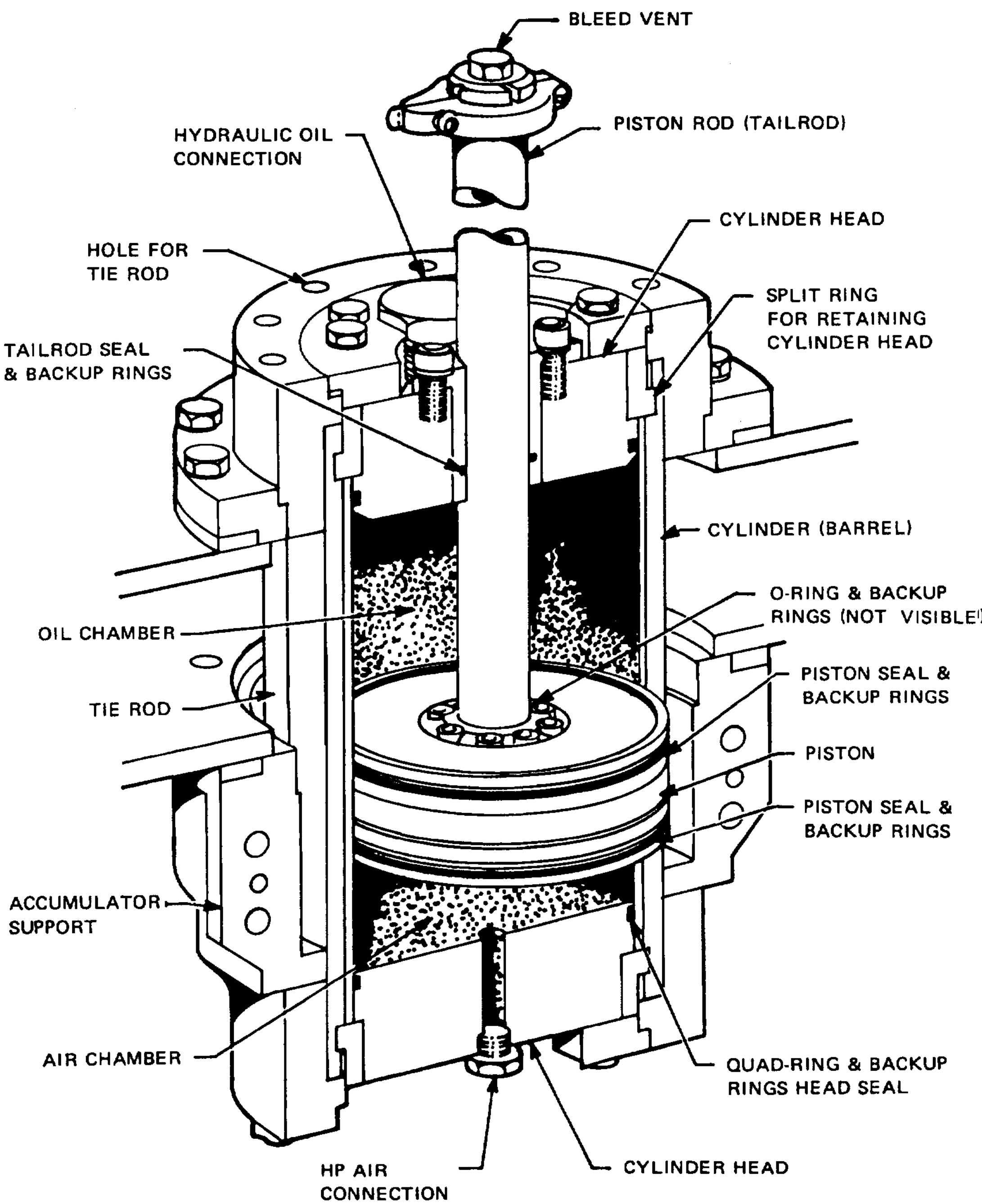
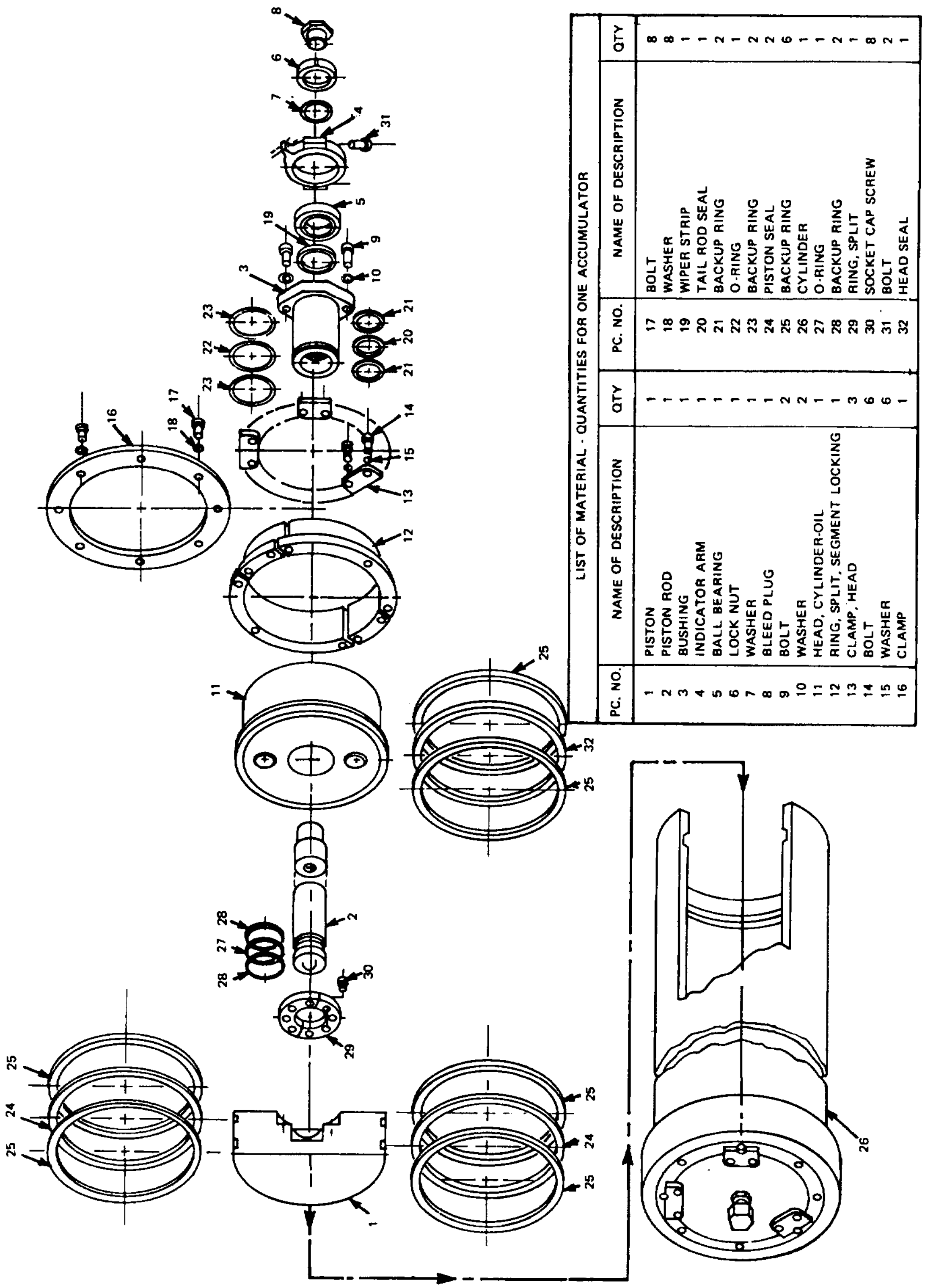


Figure 556-6-1. Cross-Section View of Piston Tailrod Type Accumulator



LIST OF MATERIAL - QUANTITIES FOR ONE ACCUMULATOR

PC. NO.	NAME OF DESCRIPTION	QTY	PC. NO.	NAME OF DESCRIPTION	QTY
1	PISTON	1	17	BOLT	8
2	PISTON ROD	1	18	WASHER	8
3	BUSHING	1	19	WIPER STRIP	1
4	INDICATOR ARM	1	20	TAIL ROD SEAL	1
5	BALL BEARING	1	21	BACKUP RING	2
6	LOCK NUT	1	22	O-RING	1
7	WASHER	1	23	BACKUP RING	2
8	BLEED PLUG	1	24	PISTON SEAL	2
9	BOLT	2	25	BACKUP RING	6
10	WASHER	2	26	CYLINDER	1
11	HEAD, CYLINDER-OIL	1	27	O-RING	1
12	RING, SPLIT, SEGMENT LOCKING	1	28	BACKUP RING	2
13	CLAMP, HEAD	3	29	RING, SPLIT	1
14	BOLT	6	30	SOCKET CAP SCREW	8
15	WASHER	6	31	BOLT	2
16	CLAMP	1	32	HEAD SEAL	1

Figure 556-6-2. Exploded View of Piston Tailrod Type Accumulator

556-6.3.3.1 Accumulator Seal Identification. The primary items of concern are the dynamic seals for the tail-rod and piston, piece numbers 20 and 24 on Figure 556-6-2. Many accumulators utilize quad-rings for these applications. A cross section of a quad-ring is shown in Figure 556-6-3. SHIPALTS SSBN 1348, SSN 1703, and SSN 2691 include replacement of the dynamic seals, quad-rings, with QUAD-O-DYN seals. A cross section of this seal is shown in Figure 556-6-4. Laboratory testing and an in-service submarine fleet evaluation have shown the QUAD-O-DYN seal to extend accumulator operating time between seal replacements significantly. The QUAD-O-DYN seal as compared to the quad-rings, differs in configuration and has higher squeeze. No groove or other physical modifications are required to utilize the QUAD-O-DYN seal; it is totally interchangeable with the quad-ring seal (except for pre-SSN759, SSN688 Class ships that have not had SHIPALT SSN2691 accomplished. These accumulators have non-standard dynamic seal grooves). NSN's for the quad-ring and QUAD-O-DYN seals for 2400 and 3600 cubic inches, accumulators in submarine service, are identified in Table 556-6-1.

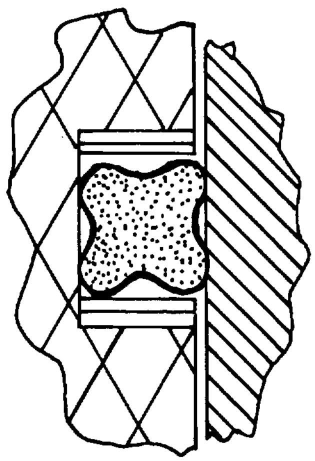


Figure 556-6-3. Quad- Ring

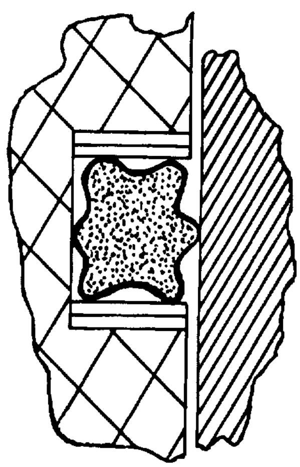


Figure 556-6-4. QUAD-O-DYN Seal

556-6.3.3.2 Accumulator Seal Wipers. The original design tailrod wiper, piece number 19 of Figure 556-6-2, consists of a strip of rubber installed in a groove on the top of the tailrod bushing, piece number 3. This wiper becomes ineffective after a few thousand cycles of accumulator operation. Therefore, this wiper should be replaced every time accumulator maintenance is performed. The NSN for this wiper strip is 9Z5330-00-768-7196. An improved wiper is available and has been provided on many accumulators by SHIPALTS SSBN 1348 and

SSN 1703. The special retaining groove for the wiper is machined into the top of the special leakage collecting device also provided under those SHIPALT's. The new wiper will not fit into the groove provided for the original wiper, as illustrated in Figure 556-6-5. When the new wiper is installed, per SHIPALT, the original wiper is eliminated; however, the groove for it remains and should be left empty. The new wiper is very effective and need be replaced only at approximately three year intervals, unless it becomes severely cut as a result of tailrod defects (nicks and dents). The improved tailrod scrapers are proprietary to C. E. Conover and Company, but are stocked in the Navy Supply System. For the lead accumulator (3-1/4-inch diameter), part number CEC-401-339-01 has been assigned NSN 9Z5330-00-442-5401. For the main and vital accumulators (2-3/4-inch rod diameter), part number CEC-401-335-01 has been assigned NSN 9Z5330-00-394-4155. When installing the Conover wiper, the elastomeric compression member (O-ring) must be in place on the wiper before installing it in the groove. The O-ring inherently has a tendency to extrude between the gland and scraper. This extrusion gives the impression that the O-ring is oversize; it is not. Patiently, work the O-ring into position using only your fingers, do not use sharp, hard tools.

Table 556-6-1. QUAD-RING AND QUAD-O-DYN IDENTIFICATION

	Piston Seal (Nominal 1/4″ Cross Section, 13″ ID) NSN	**Main & Vital Tailrod Seal (Nominal 3/16″ Cross Section, 2-3/4″ ID) NSN**	**Lead Tailrod Seal (Nominal 3/16″ Cross Section, 3-1/4″ ID) NSN**
Quad-ring	5330-00-551-9014	5330-00-640-9017	5330-00-582-2521
QUAD-O-DYN	5330-00-124-1692	5330-00-122-9641	5330-00-124-1722
NOTE: The static seal used on the cylinder heads is the identical Quad-ring as that used on the piston. The use of the QUAD-O-DYN seal in cylinder head static applications is not recommended because the increased squeeze will make assembly more difficult and is unnecessary.			

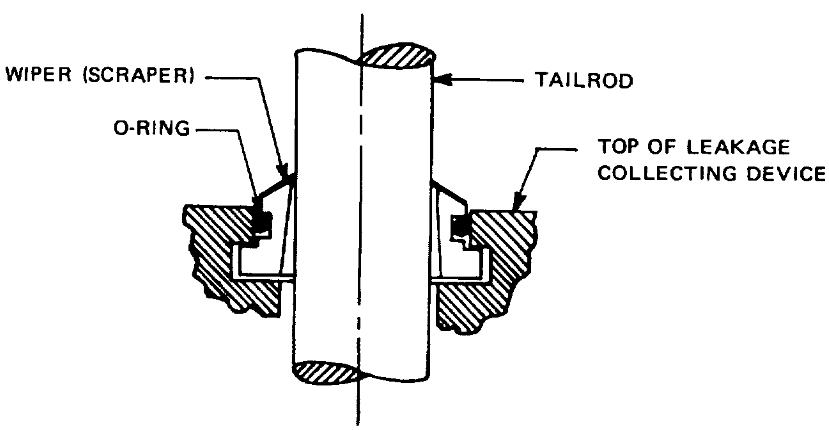


Figure 556-6-5. Improved Tailrod Wiper

556-6.3.3.3 Dynamic Seal Failure Criteria. Dynamic seal failure criteria presented in paragraph 556-6.3.3.4 is applicable to hydraulic system power plant accumulators only. Flood control accumulator leakage criteria is currently specified in applicable URO-MRCs. Accumulator dynamic seal replacement should be accomplished when the oil leakage rate reaches two pints/day, or when air leakage is readily detectable at the tailrod leakoff vent by an audible hiss. Air leakage should not be allowed to attain a level such that the air flow picks up oil from the tailrod vent and results in escaping oil mist.

556-6.3.3.4 Measurement of Dynamic Seal Oil Leakage. 2400 and 3600 cu. in. accumulators for the SSBN726 and SSN688 classes and accumulators modified by SHIPALTS SSBN 1348 and SSN 1703 have an oil leakage collection bottle. Measurement of oil leakage is simply a matter of observation. Since the leakage collected in the bottle is the total combined piston seal and tailrod seal leakage, and the effort to change a tailrod seal is much less than changing piston seals, the following investigative approach is recommended to identify which seal needs replacement.

1. Remove a portion of the oil from the tailrod vent hole and note the level.
2. After a period of time check the level again; if the level has increased, the leakage is from the piston. If the level in the tailrod has not increased, the tailrod seal is the problem. If the tailrod vent hole does not overflow, the increase in oil in the collection bottle represents tailrod seal leakage. On SSBN640 Class, SSN637 Class, and a few other ships, if the accumulators have not been modified by SHIPALT, the oil leakage will collect in the recess created by the oil head being lower than the top of the cylinder flange. Although not simple and convenient to do, measurement of oil collected in the recess will reflect leakage volume. On the remaining ships where the oil head is flush with the top of the cylinder, leakage measurement is difficult. Partial draining of the tailrod vent hole and observation of the rate which it fills will indicate piston seal leakage. A leakage rate of two pints/day will cause the tailrod vent hole oil level to rise at an average rate of two inches/hour. Tailrod seal leakage must be evaluated during a period when the tailrod vent is not overflowing. The condition of the seal (leakage) can only be based on observation of the mess it creates.

556-6.3.3.5 Accumulator Disassembly. This procedure is not a complete step-by-step sequence, but a general procedure which highlights critical steps. Slight variations may be necessary for specific accumulator assemblies and installations.

NOTE

Numbers in parenthesis refer to piece numbers of Table 556-6-2 and Figure 556-6-1, Figure 556-6-2, and Figure 556-6-6.

1. Isolate and tag out all accumulator oil and air lines and follow normal submarine accumulator overhaul precautions. Vent and drain, completely, both oil and air sides of the accumulator before starting physical disassembly. Discharge oil side first so that accumulator will not be full of oil when disassembled.
2. Disconnect all necessary piping and remove the oil contents indicator mechanism. Install clean plastic pipe caps, or tape clean metal plates on all open lines to prevent system contamination.
3. Install plastic pipe caps on the threads of the oil fittings in the upper head. Puncture the caps liberally for venting when the piston is moved. Check to see if the hex portion of the oil fitting will clear the split ring segment when the head is depressed. If not, the fitting must be removed and the hole taped to exclude dirt from the cylinder.
4. Remove capscrews (9) and washers (10) which hold the tailrod bushing (3) to the cylinder oil head and remove the bushing, and the oil leakage collecting device if installed (see Figure 556-6-2).
5. Cut an appropriate size rectangular piece of rubber sheet stock or gasket material, wrap around tailrod, and secure in place using tape. This will serve as protection to the tailrod during disassembly.
6. Install the head lifting device (34) (Table 556-6-2). Attach the lifting device to the head (11) by using the two previously removed bolts (9) (Figure 556-6-2). If the head lifting device is not available, it can be manufactured using the detail drawing (Figure 556-6-6). Likewise in step 16, reference is made to a piston lifting device (36). This device is also shown on Figure 556-6-6. Upon completing manufacture, and prior to initial use, the devices shall be tested as shown in Figure 556-6-7.

7. Use a suitable hoisting arrangement for lifting the head, such as shown in Figure 556-6-8. Take up the slack in the hoist.

CAUTION

Use only enough force to support and maintain control of the head when the clamps are removed.

8. Remove the head clamps (13) by removing the bolts (14) and washers (15) (Figure 556-6-2).
9. Lower the head (11) beyond the segment rings (12). If the head (11) does not go down under its own weight, then perform steps 9.a through 9.e (Figure 556-6-2):
   - a Remove the three flange bolts (17) located adjacent to the previously removed clamps (13) (Figure 556-6-2).
   - b Position the head clamps and metal blocks (40) as shown in Figure 556-6-9.
   - c Install and hand tighten the previously removed flange bolts (17) to the clamps (Figure 556-6-2).
   - d Rotate each bolt a few turns at a time to evenly distribute the load on the head and to break it loose. Do not let head get cocked in the cylinder. Remember to leave a little slack in the hoisting cable so the head can move down into the cylinder.
   - e With the head lowered below the segment rings, remove the flange bolts, clamps, and metal blocks.
10. Remove the segment (12) (Figure 556-6-2).
11. Lift and remove the head (11) (Figure 556-6-2).

WARNING

Do not use air pressure to lift head.

12. Remove the flange clamps (16) by unscrewing the remaining five bolts (17) and five washers (18) (Figure 556-6-2).
13. Change the hoisting arrangements, and use the head lifting device (PC No. 35, eyebolt, for SSN 688 and SSBN726 classes) to lift the piston and rod assembly, as shown in assembly A (position A’ for SSN688 and SSBN726 classes) of Figure 556-6-10.
14. Lift the piston and rod assembly as high as possible.
15. Remove two bolts (30), 180 degrees apart, from the plate and the piston (1) (Figure 556-6-2).
16. Attach the piston lifting device (36) to the piston using the two capscrews (37).
17. Change the Hoisting arrangement to remove the piston and tailrod assembly as shown in position B of Figure 556-6-10.

CAUTION

Attach one chain hoist to one side of the piston lifting fixture before removing the head lifting device from the piston rod, in rigging from position A to position B.

18. Using the hoist to lift, manually guide the piston and rod assembly out of the accumulator. Use extreme care to prevent scoring of the piston with the cylinder walls. Set the piston down gently on a flat surface. Protect the bottom of the piston with a layer of clean rags.

19. With the piston and rod assembly sitting firmly on a flat surface, further disassembly is required in order to replace the O-ring and backups, pieces 27 and 28 (Figure 556-6-2). Oil leaking past this seal will produce leakage out of the tailrod opening the same as a bad piston seal. Therefore, always replace this seal when replacing piston seals. The socket head capscrews, piece 30, usually have drilled heads and are lockwired in place. Before removing these capscrews, it is advisable to match-number each screw and the respective tap-hole from which it is removed. Reassembly with the capscrews in the same spot as before will ensure that the holes drilled in the capscrews will align up for each lockwiring. Otherwise trial and error fitting of capscrews and holes will be necessary to get an orientation of the drilled head holes which will allow a lockwire to be fed through.

20. If it is desired to replace the air side cylinder head seal, then perform steps 20.a through 20.e below:

    a Disconnect the air piping from cylinder head.

    b Install the air head lifting device, as shown in Figure 556-6-11, through the air port in the head. Details for the lifting device are shown in Figure 556-6-12. Thread the nut approximately six inches up on the threaded stock and with the washer held next to the nut, insert the stock through the air connection port. Place the threaded plate under the air head and thread on until the nut, washer and plate are firmly against the head. The threaded stock should extend at least two threads beyond the plate. If thread protrusion is inadequate or excessive, reposition the nut and retighten the assembly.

    c Using a suitable hoisting arrangement attached to the eyebolt, take up the slack in the hoist mechanism.

CAUTION

When the head clears the segment rings they are free to fall out - remove the segments cautiously.

    d Remove the lower cylinder head clamps, and raise the cylinder head beyond the segment rings, and remove the segment rings.

    e The air side cylinder head may now be lowered from the accumulator barrel and the seal and back up rings replaced.

NOTE

Aboard some ships a significant amount of interference (other equipment and piping) exists on the underside of the accumulator. It has been demonstrated that the lower head can be removed by hoisting it up the full length of the accumulator. If this procedure is chosen, proceed cautiously to avoid cocking the head and wedging it in the accumulator barrel. Do not attempt this procedure unless a hoisting arrangement can be setup which will give a nearly perfect vertical pull.

21. Reinstallation of the lower head is simply the reverse of the disassembly. Installation of the guide pieces (see paragraph 556-6.3.3.8.) will aid inserting the head into the barrel.

Table 556-6-2. LIST OF MATERIALS FOR AN ACCUMULATOR LIFTING DEVICE

Quantities for One				
PC. No.	**Name or Description**	**Qty**	**Material**	**Spec.**
33	Hoist, chain 1/2 ton capacity	2	Steel	MIL-H-904
34	Head, lifting device	1		
34-S1	Plate, 10.2 (1/4″)	1	Steel	MIL-S-22698
34-S2	Tubing, 4.00″ OD x 0.198″ wall x 3-3/8″ long	2	Steel	MIL-T-20157
34-S3	Plate, 20.4 (1/2″)	1	Steel	MIL-S-22698
35	Piston lifting device	1	Steel	
35-S1	Adapter	1	Steel	MIL-S-22698
35-S2	Eyebolt, 3/4-10 UNC, eye collar type	1	Steel	NSN 5306-00-272-2136
36	Piston, lifting device	1		
36-S1	Plate, 20.4 (1/2″)	1	Steel	MIL-S-22698
36-S2	Spacer, 1/8″ thick	2	Steel	MIL-S-22698
36-S3	Eyebolt, regular 3/4″ dia x 6″ long with nut	2	Steel	
37	Screw, cap sch. 1/2″ D-13 UNC-2A-2-1/2″ long	2	Alloy Steel	NAS 1352-8-40
38	Line, manila 1/2″ dia	10 ft		
39	Sheave	1	Steel	
49	Metal block, 1″ x 1″ 3/8″ thick	3	Steel	
NOTES:1. All tapped holes to be chamfered2. Piece 36-S3 to be regular nut eyebolt3. Piece 34, 35, and 36 are spare parts used to remove the piston and rod assembly, and the head.				

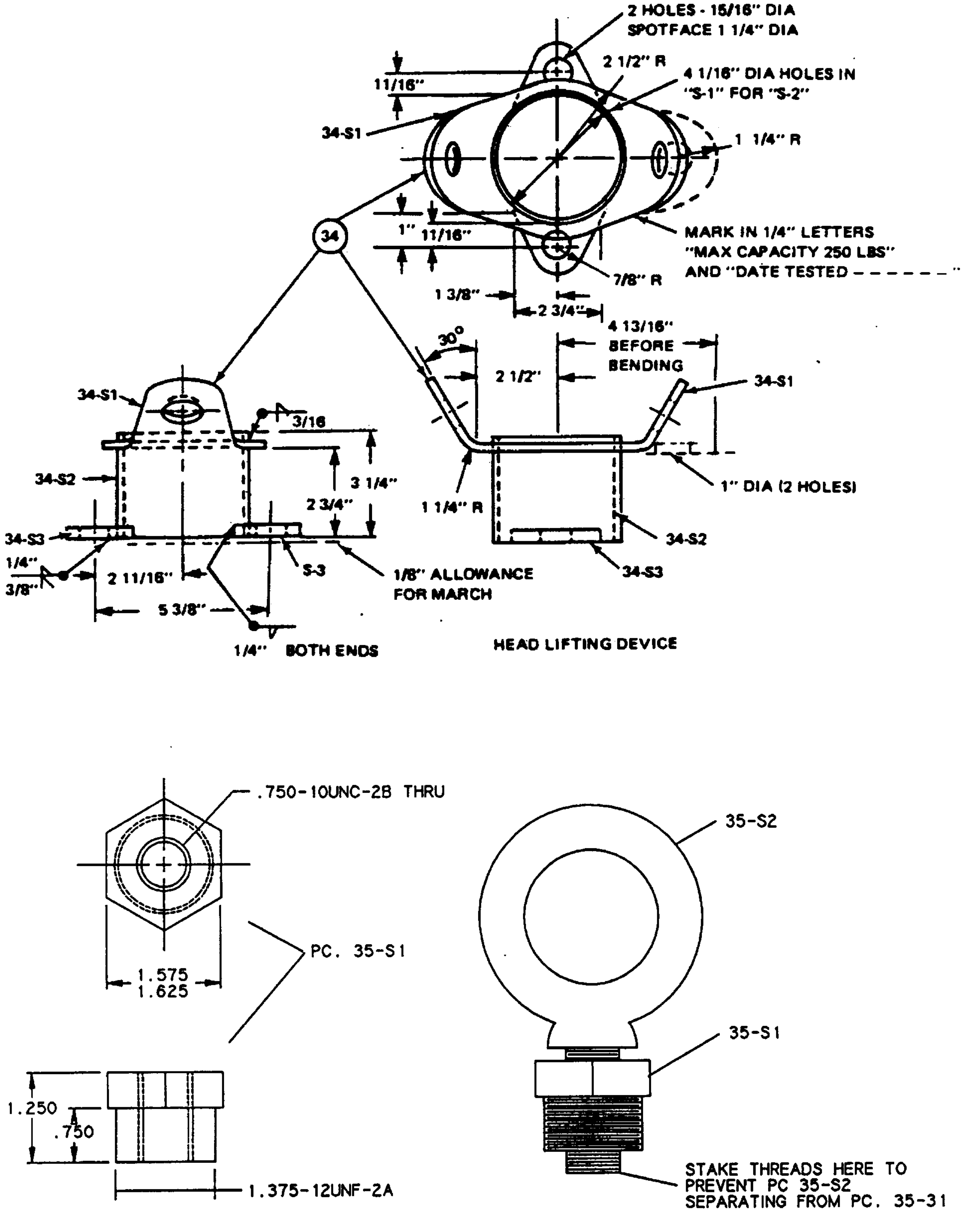


Figure 556-6-6. Accumulator Lifting Devices (Sheet 1 of 2)

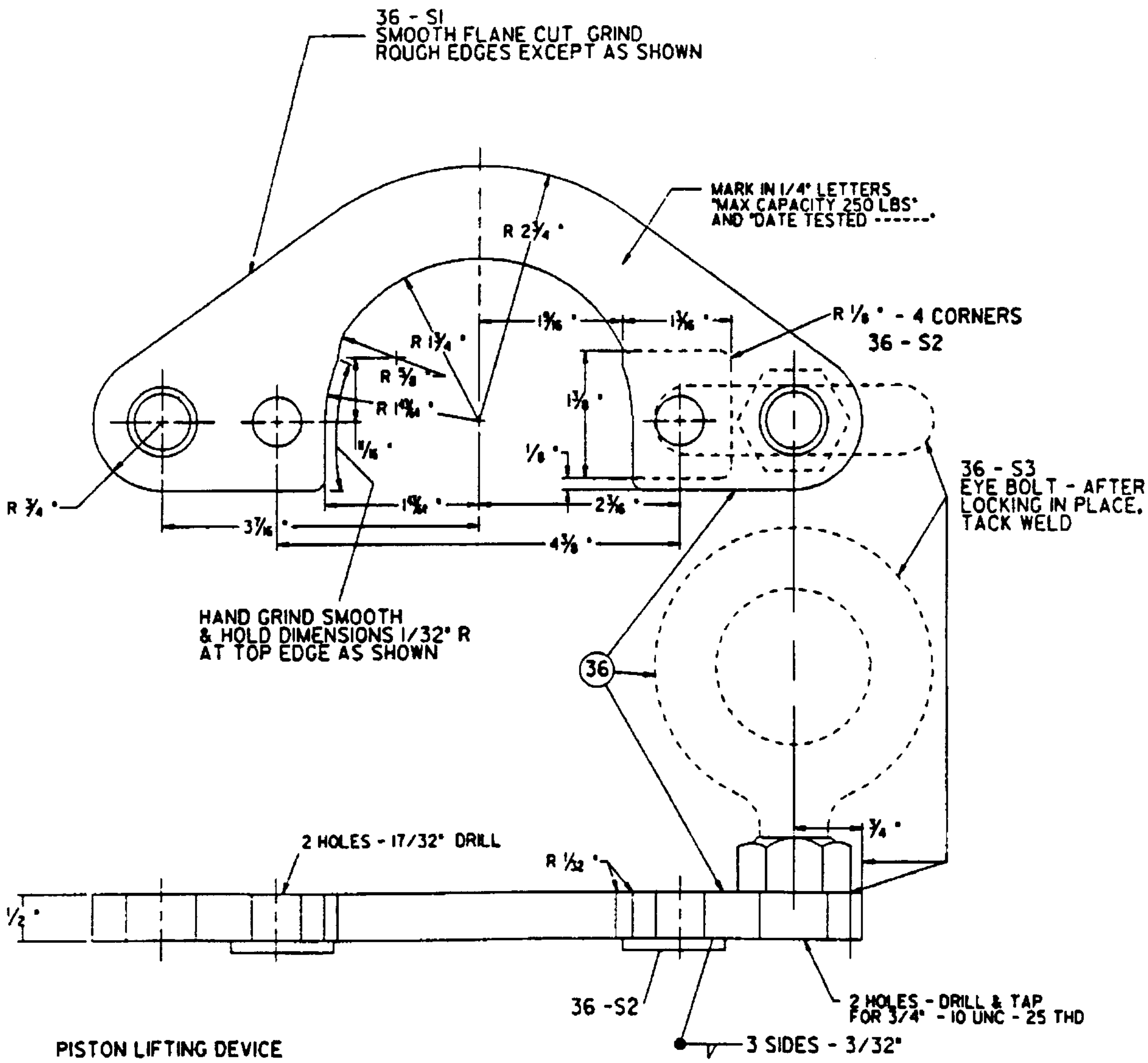


Figure 556-6-6. Accumulator Lifting Devices (Sheet 2 of 2)

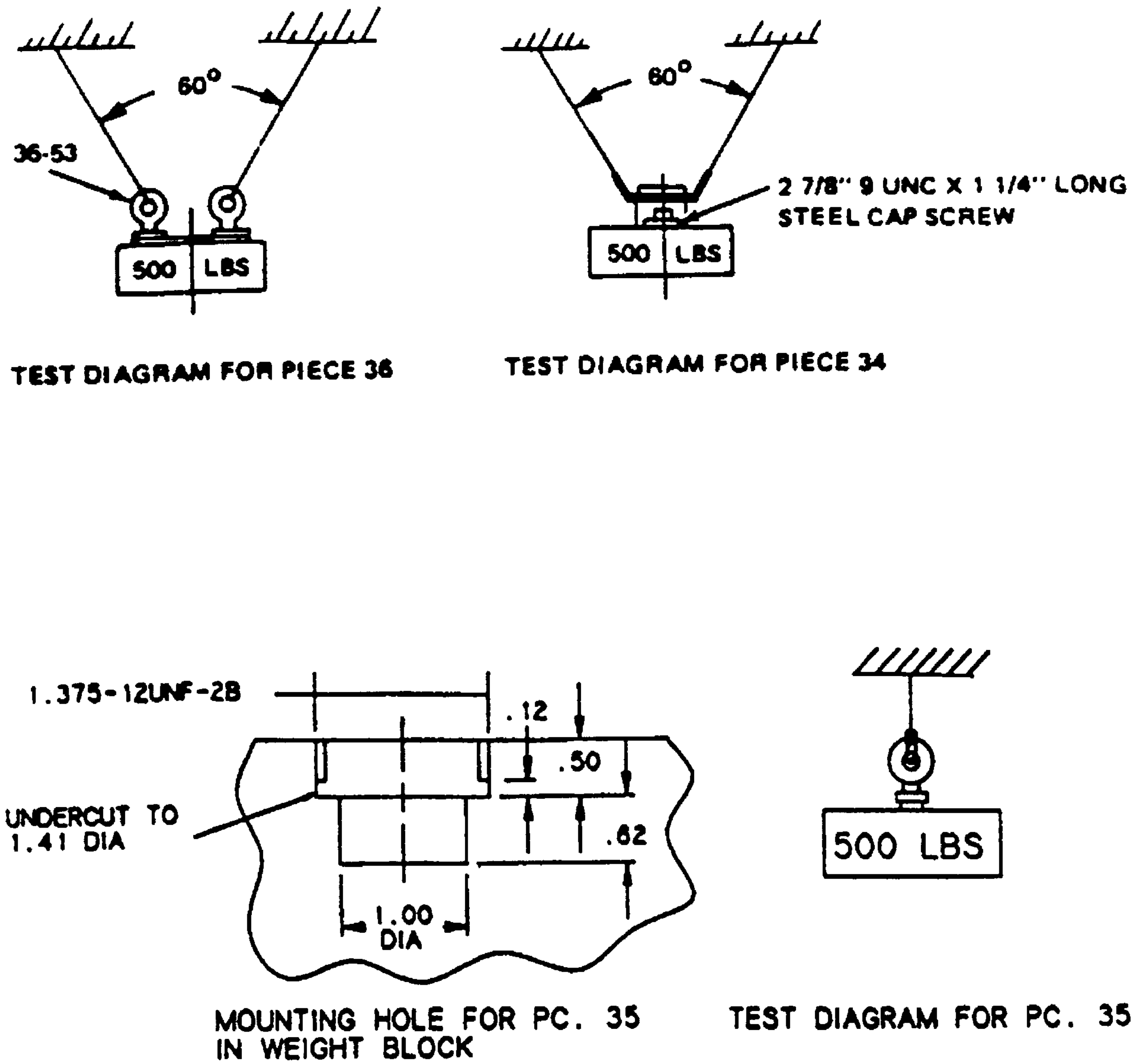


Figure 556-6-7. Tests for Accumulator Lifting Device

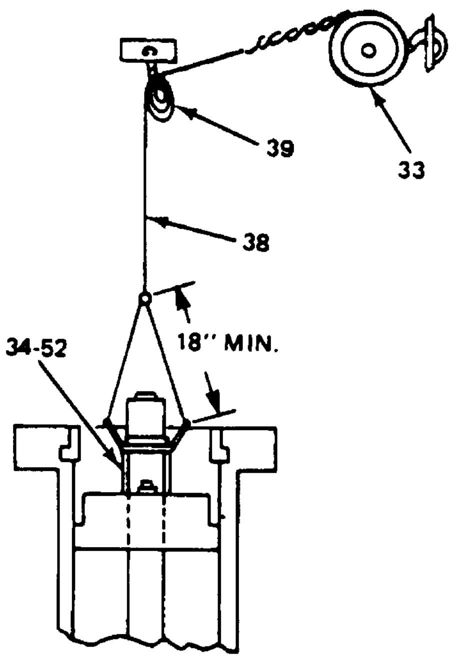


Figure 556-6-8. Typical Hoisting Arrangement

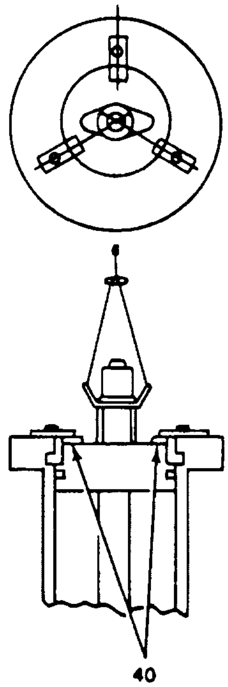
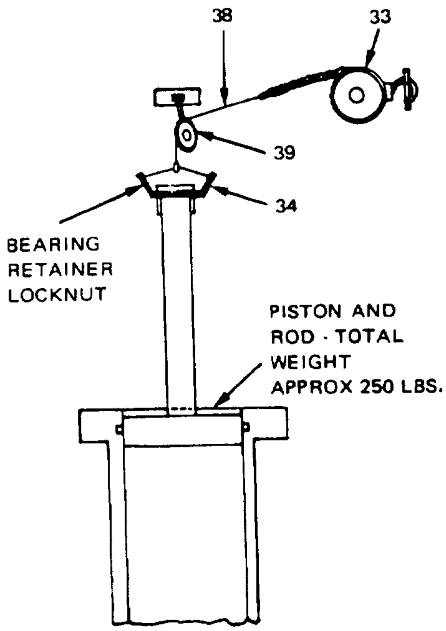
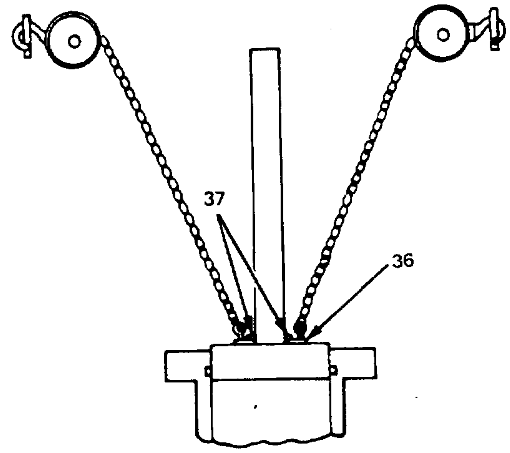


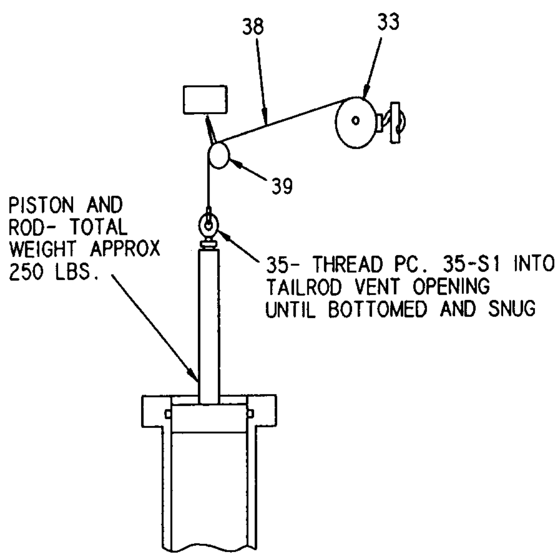
Figure 556-6-9. Breaking Head Loose



POSITION A - LIFTING PISTON AND ROD



POSITION B - REMOVAL OF PISTON AND ROD



POSITION A′ LIFTING PISTON AND ROD

Figure 556-6-10. Lifting and Removing Piston and Rod

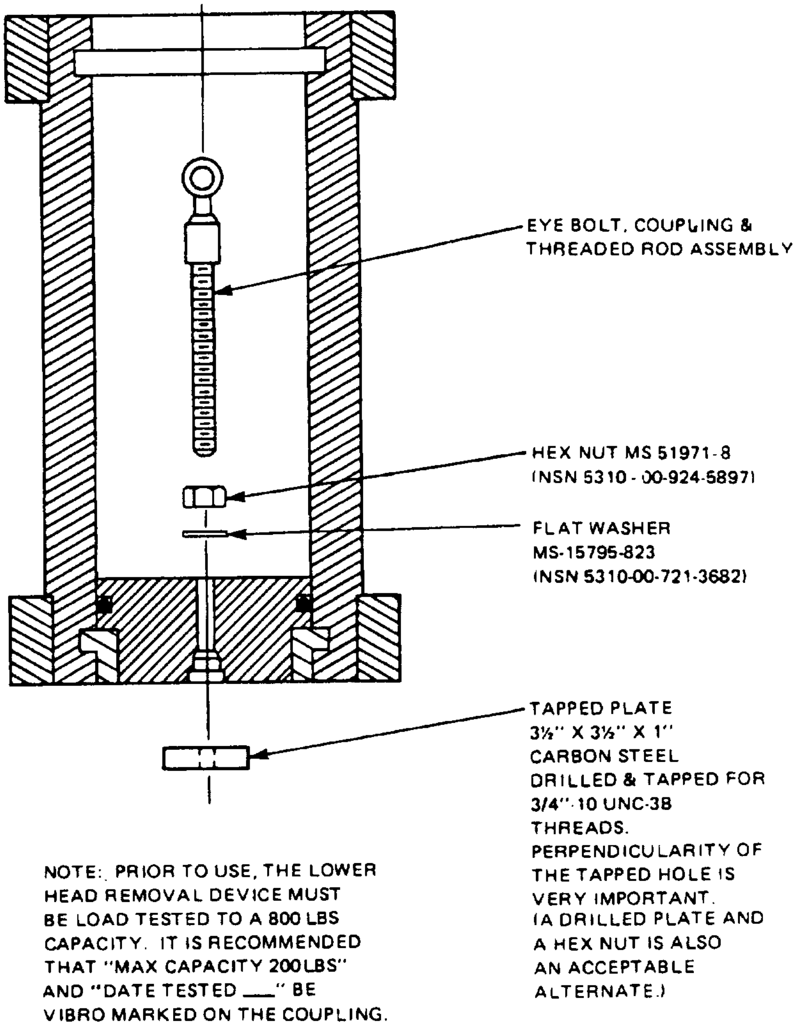


Figure 556-6-11. Accumulator Air Head Lifting Device

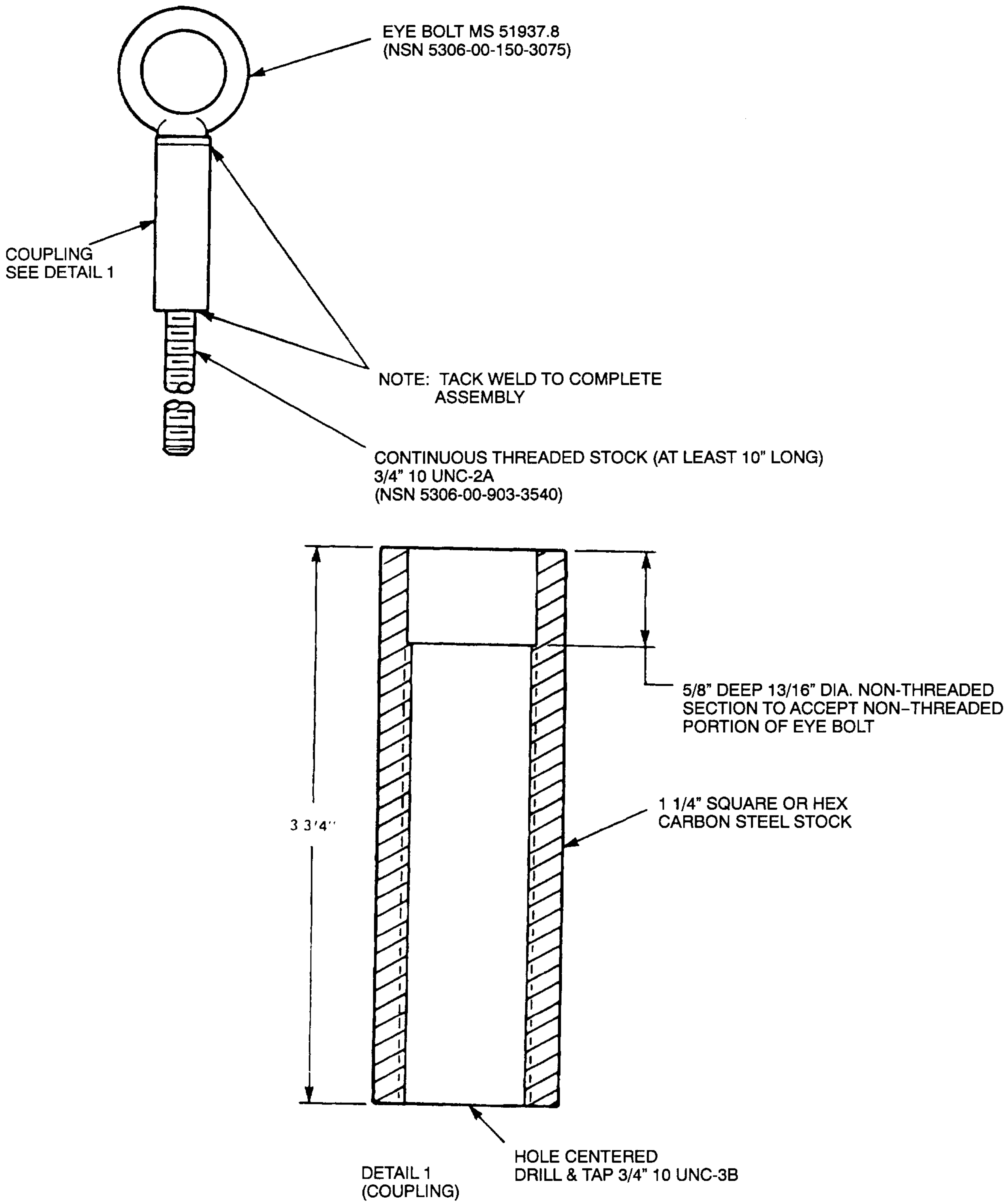


Figure 556-6-12. Detailed Accumulator Air Head Lifting Device

556-6.3.3.6 Inspection of Accumulator Components. Inspect accumulator cylinder and tailrod using the applicable Technical Repair Standard (TRS) as a guide. Remove all nicks and burrs to prevent damage to components and seals during assembly. Repair all score marks (scratches) on the piston tailrod and cylinder wall. Minor repairs can be accomplished by stoning to remove the rough edges and polishing with crocus cloth. Stoning and polishing strokes must be around the diameter and not along the axis. If the score marks cannot be completely removed and be within the specifications of the TRS, then schedule the accumulator for overhaul or replacement at the earliest availability. If a specific accumulator consistently displays early seal failure and the seals appear nibbled or extruded when removed, a thorough inspection is recommended using the applicable accumulator detail drawing and TRS as guides to verify proper dimensions, clearances, and seal squeeze.

556-6.3.3.7 Dynamic Seals and Backup Rings Installation. During reassembly it is very important that all backup rings and seals are thoroughly lubricated. Lubricate them with clean system fluid or a thin, uniform coating of system compatible grease on all surfaces. It is important not to get grease under the O-rings and backup rings; that is, between the ring and the bottom of the ring groove. The reason for this is that when the seals are squeezed during installation, the grease will push the backups out of the groove and cause interference, prohibiting assembly. Therefore, first clean out all old grease and other residue from the seal grooves. Then install the dynamic seals in the seal grooves and then install a backup ring on each side of the seal. These backup rings are usually double-turn split backup rings (from end to end the ring circles the piston twice). To aid in achieving a fully inserted backup ring, press one end into the groove, trace the path of the ring, applying continuous pressure on the edge of the ring. Repeat as many times as necessary to result in the ring properly set in the groove. Next, sparingly smear the grease over the installed rings to provide lubrication and hold the rings in place. In particular, the split ends of the backup rings are prone to popping out of the groove and may require a heavier coat of grease. Remember, too much grease may work its way behind the rings and push the backup out of the groove. The installed rings must be flush with the outer diameter of the groove surface, as shown in Figure 556-6-13. The incorrect installation shown in Figure 556-6-13 will cause much difficulty when attempting to assemble the piston into the cylinder. A backup sticking out as little as 1/32 of an inch can cause extreme problems as it can hang up on a chamfer during assembly.

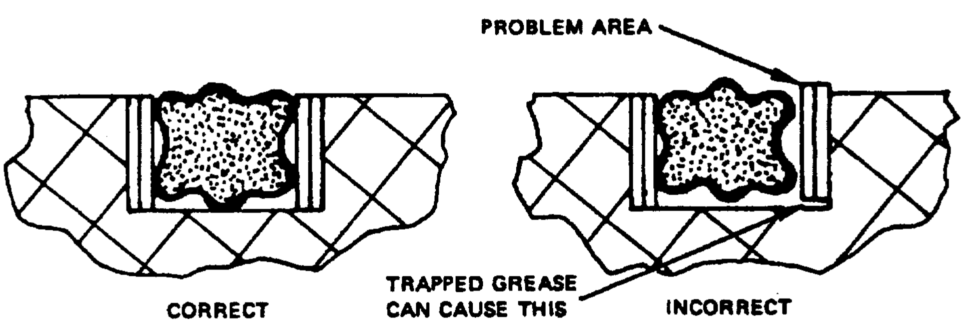


Figure 556-6-13. Installed Packing Examples

556-6.3.3.8 Accumulator Reassembly. The most important step in achieving a successful accumulator overhaul, and the most difficult, is getting the piston into the cylinder without damaging the seals or backup rings. Patience is a necessity. The procedure in subparagraphs 1 through 6 must be followed:

1. Install guide pieces into the groove in the cylinder, which is normally occupied by the split segment ring (12) (Figure 556-6-2). The guide pieces are commonly referred to as bones. These pieces eliminate the possibility of the seals striking the edges of the groove and moving out of position. A three-piece set of guide pieces is available under NSN IH5120-00-678-5119 (2,400- and 3,600-cubic inch accumulators). These pieces are removed once the piston is fully inserted in the cylinder.

2. Apply a film of lubrication (system fluid) to the upper half of the cylinder by hand.

3. Align the axis of the piston and tailrod assembly exactly with the axis of the cylinder and lower the assembly slowly.

CAUTION

Patience during the following critical step is absolutely necessary.

4. Do not force the piston into the cylinder. Let the weight of the assembly be the driving force. If the piston hangs up and will not drop in, manually shake (vibrate) the end of the tailrod; this frequently aids in assembly. Also, it may be necessary to hit the piston with a rubber mallet in order to aid the entry of the piston into the cylinder. Do not hit the piston continuously on one spot for this will cock it in the cylinder; distribute the blows uniformly about the top of the piston. Take care not to damage the piston or piston rod when hitting the piston. If the assembly does not enter the cylinder with several sharp hits with the mallet, it is most likely hung up on a backup ring. QUAD-O-DYN seals have more squeeze than quad-rings, but installation is only slightly more difficult. Lift the piston and rod assembly up, ensure that the backup rings are in proper position, and try again. This step may have to be repeated several times.

5. Once the piston is in the cylinder the reassembly is simply the reverse of the disassembly procedure.

NOTE

To allow easier alignment with ship's piping, adhere to the following: when installing the oil side head clamp bolts (14) (Figure 556-6-2), do not tighten (loosen these bolts after installation of pre-assembled accumulators); this will allow the head to be rotated to align with ship's piping. After aligning pipe and tightening up all piping joints, **tighten the head clamp bolts** to specified torque.

6. Prior to reinstallation of the bleed vent plug on the end of the tailrod, the vent hole in the tailrod shall be filled with clean system fluid. This fluid will fill the void between the piston seals and provide lubrication for the air side seal. Without this lubrication the air side seal may run excessively dry and rapid wear can result.

556-6.3.4 BLADDER TYPE ACCUMULATORS. Bladder or bag type accumulators consist of a shell or case with a flexible bladder inside the shell.

The bladder is precharged with air or inert gas to a specified value. Fluid is then forced into the area around the bladder further compressing the gas in the bladder. This type accumulator has the advantage that so long as the bladder is intact there is no exposure of fluid to the gas charge and therefore less danger of an explosion.

556-6.3.5 DIRECT CONTACT GAS-TO-FLUID ACCUMULATORS. Direct contact gas-to-fluid accumulators generally are used in very large installations where it would be very expensive to require a piston or bladder type accumulator. This type of accumulator is used in airplane elevator hydraulic systems where several thousand gallons of fluid are needed to supplement the output of the hydraulic pumps when raising the elevator platform. The direct contact between the air or gas and the hydraulic fluid tends to entrain excessive amounts of gas into the fluid. For this reason direct contact accumulators are generally not used for pressures over 1200 lb/in^2 g. The use of this type accumulator with flammable fluid is dangerous because there is a possibility of explosion if any oxygen is present in the gas and pressure surges generate excessive heat. For this reason, safety fluids are used in this type of installation.

556-6.3.6 SAFETY PRECAUTIONS FOR ACCUMULATOR LOADED SYSTEMS. A charged accumulator, particularly in larger size units, represents a considerable source of energy. Careless opening of a valve can cause an actuator to operate, or some action to take place which could endanger personnel or equipment.

a. Always know the operational status of all the equipment that could be affected by sudden pressurization of a system before opening any valve which is isolating a charged accumulator.

b. Rapid opening of a valve that had been isolating a charged accumulator from a hydraulic system can cause an explosion. If a quantity of air is trapped in a system and the system has a flammable oil as the hydraulic fluid all the requirements for compression ignition are present. Sudden application of pressure from a charged accumulator may cause an associated temperature rise in the entrapped air until the flash point of the vapor is reached. Because the principle of this type explosion is similar to the compression ignition in a diesel engine, this type explosion is frequently called diesel ignition. Compression ignition has been a suspected cause in several serious explosions on Navy ships. To prevent compression ignition always open valves which pressurize other parts of a system, very slowly.

c. Other precautions which should be observed are:
   1 Keep oil from the air side of accumulators.
   2 Keep air out of the hydraulic system.
   3 Purge air flasks or separate oil from the air being used to charge accumulators.
   4 If continued severe pressure surges are noticed in a system, secure the system and correct the trouble.

SECTION 7.

FILTRATION

556-7.1 GENERAL

556-7.1.1 The need for clean hydraulic systems on shipboard installations cannot be overemphasized. Contaminated systems will generate additional corrosion and wear debris, and will result in component malfunctions such as sticking control valves, leaking seals, and premature equipment failure. Hydraulic systems can tolerate certain levels of contamination without serious consequences. Systems contain some contamination even before being put into operation. Proper assembly, installation, and flushing procedures usually ensure that only a minimum amount of dirt remains in a new or overhauled system. Once the system becomes operational, corrosion and wear products are continually generated, and (together with residual contaminants) will soon cause problems if unchecked. The purpose of filters is to prevent solid contaminants from increasing to troublesome levels.

a. System cleanliness is frequently maintained through the use of relatively large full flow filters, (referred to as the main or primary filters) generally installed in pump discharge, pump suction, and return line locations. In addition, filters may also be found in the supply lines to critical components or integral with the component itself. These supplemental filters are intended to keep the components or subsystems clean, in the event that the primary system filters do not maintain adequate system cleanliness. Generally, the supplemental filters for critical components have much lower dirt capacity than the primary system filters, and will rapidly become clogged if the system is dirty. Systems should not be operated if an installed filter element is known to be clogged or the fluid is bypassing the element, a condition possible when the filter has a bypass relief arrangement (see bypass definition, paragraph 556-7.2.1). To prevent malfunctions of downstream components from continued operation in the bypass mode, plugging or deletion of bypass relief valves has been authorized on many filter assemblies. Without a bypass valve the installed filter elements must be capable of withstanding total system pressure without collapse, and a pressure relief valve must be located upstream of the filter to prevent system damage from overpressure. Examples where filter bypasses are being eliminated include submarine pump discharge filters and servo-valve pilot supply lines. A clogged filter which does not have a bypass may reduce the amount of fluid reaching the serviced components downstream. For filter assemblies with bypass reliefs, operating with a clogged filter allows contaminants to bypass the filter, and trapped particles may even be flushed off the element and through the bypass relief.

b. If the filter provided on a piece of equipment is obviously not suited for the service required (for instance, if components still fail due to contamination or a filter element loads up too frequently), the system life cycle manager should be advised of the deficiency.

556-7.2 DEFINITIONS

556-7.2.1 Personnel responsible for maintenance of hydraulic equipment should be familiar with the terminology used in regard to filtration. A few of the more common terms are discussed below. Micrometre (formerly micron). A unit of length, approximately 0.00004 inches. The smallest particle visible to the human eye is about 40 micrometres in diameter.

a. Micrometer (formerly micron). A unit of length, approximately 0.00004 inches. The smallest particle visible to the human eye is about 40 micrometers in diameter.

b. Filter. A device for the removal of solids from a fluid, usually rated in micrometres (microns) in accordance with the size of the solid removed, and classed as cleanable or non-cleanable (disposable) depending upon the material of construction. Also referred to as a filter element.

c. Filter Housing. The container for filters. Also referred to as a filter manifold.

d. Filter Assembly. A unit composed of a filter (element) and filter housing.

e. Depth Filters. Filters which are constructed of essentially a random orientation of matter in compacted mat or bed form. Fluid passes a tortuous path through irregular channels defined by this orientation, and particles are retained through the depth of the filter. Depth filters are capable of holding large quantities of solids and removal of very fine particles.

f. Screen (surface) Filters. Filters which are constructed of basically homogenous material arranged in a given geometry to define pores and passages of predetermined size. Fluid passes an essentially straight path and particles are retained on the surfaces of the filter.

g. Indicating Filter Assembly. A filtering assembly in which the differential pressure across the filter element is used to actuate a pointer or indicator, which shows that the filter element has reached its rated dirt-holding capacity. (The indicator may also show when the bypass relief opens, and part of the fluid stream is no longer being filtered.)

h. Full Flow Filter Assembly. A filter assembly designed and installed so that all of the fluid flowing in the portion of the system in which the filter assembly is installed will normally pass through the filter element.

i. Proportional or Partial Flow Filter Assembly. A filter assembly which receives only a portion of the total flow of fluid in the system. Generally the supply for the filter is from a high-pressure line, through a small orifice, through the filter, and back to the system reservoir. This type assembly is sometimes called a bypass filter assembly and should not be confused with full-flow filter assembly having a built-in bypass relief valve.

j. Strainer. A filtering device for the removal of solids from a fluid where the resistance to motion of such solids is in a straight line. A strainer is usually a wire screen and is used primarily to remove larger particles.

k. Filter By-Pass. A feature built into some filter assemblies wherein a passage is provided directly from inlet to outlet. This passage normally is closed by a spring-loaded poppet valve so that fluid is routed through the filter element. When the differential pressure required to force fluid through the element is greater than the poppet valve spring pressure, the valve will open and a portion of the fluid will no longer pass through the filter element.

l. Filter Element Differential Pressure. The difference between the fluid pressures at the inlet and outlet of the filter element. This value indicates the pressure required to drive the fluid through the filter element.

m. Differential Pressure Gage. A single gage which indicates differential pressure. If two pressures are indicated by two pointers, one value must be subtracted from the other. If one pressure is indicated, that value is the differential pressure, the subtraction having been done within the gage.

n. Terminal Pressure. The maximum differential pressure at which a filter element is tested for efficiency and dirt capacity. May also be used to indicate the differential pressure at which the element should be replaced.

o. Dirt Capacity. A measure of the amount of contaminant that a filter element can retain at a specific terminal pressure.

p. Collapse Pressure. The differential pressure at which the element suffers permanent deformation or a significant reduction in performance.

q. Flow Fatigue. The ability of an element to resist a structural failure of the filter medium due to flexing caused by cyclic differential pressure. It is a measure of the element's ability to withstand pulsating flow.

556-7.3 FILTERS AND STRAINERS

556-7.3.1 SURFACE AND DEPTH FILTERS. Filters generally may be divided into two classes, surface and depth filters. A surface filter performs its function on a single geometric surface. A simple example is a window screen. On the other hand, depth type filters employ a series of surfaces throughout the filter media by creating tortuous passages through which the fluid must traverse. A typical example is a cigarette filter. Every type of filter medium has certain advantages and disadvantages. Surface type filters usually have a rather uniform pore size which provides a relatively sharp maximum particle-passed cutoff point. Depth filters on the other hand must contain passages larger than the rated size of the filter if particles are to be retained in the depth of the media rather than on the surface. Consequently there is a statistical probability that a rather large particle may pass through a depth type filter. For the same absolute rating, the majority of pores in a depth filter will be smaller than the pores in a surface filter. Therefore, while the absolute rating may by identical, the depth type filter will remove a much larger percentage of the fine particles than will the surface filter. The primary advantages of depth type filters are (1) large dirt holding capacity, (2) removal of high percentage of fine particles, and (3) lower cost. The primary disadvantages are the possibility of particle migration through the media and channeling (formation of a direct passage through the media). The primary advantages of a surface type filter are the facility for absolute filtration (a discrete particle size cut-off point) and the resistance to media migration and failure under conditions of high flow shock, and vibration.

556-7.3.2 STRAINERS. Strainers are used primarily to catch only very large particles, and will be found in those applications where this type of protection is required. Most hydraulic systems have a strainer in the reservoir at the inlet to the suction line of the pump. This strainer is usually a 50 mesh or finer screen (see Table 556-7-1) which serves to prevent larger particles of contamination from getting into the pump. A strainer is used in lieu of a filter to reduce the chance of being clogged and starving the pump. However, being located in the reservoir, maintenance of this strainer is frequently neglected. When heavy dirt and sludge accumulate on the suction strainer, the pump soon begins to cavitate. Destruction of the pump follows quickly. Unless otherwise required by equipment manuals or the MRC's, suction strainers should be checked and cleaned at least once each six months or more frequently if inspection shows that dirt or sludge is heavy.

Table 556-7-1. SCREEN SIZES (U.S. SERIES)

U.S. Sieve Number	Meshes/Linear Inch	Opening (in inches)	Opening (in Micrometres)
50	52.36	0.0117	297
70	72.45	0.0083	210
100	101.01	0.0059	149
140	142.86	0.0041	105
200	200.00	0.0029	74
270	270.26	0.0021	53
325	323.00	0.0017	44

556-7.4 FILTER MEDIA RATING CHARACTERISTICS

556-7.4.1 RATING CHARACTERISTICS. Filter ratings are used to measure and specify the performance characteristics of elements. The most significant characteristics are flow rating, particle removal efficiency and the dirt capacity of the element. In the past many of the rating methods used by filter manufacturer's were rather arbitrary and were of limited value in comparing the performance of different elements. The following paragraphs describe what various filter ratings mean.

556-7.4.1.1 Efficiency Ratings. Efficiency ratings measure the ability of the element to remove contaminants. Efficiency ratings can be based on the percentage removal by weight, by size particle removed or by a filtration ratio using a specific contaminant.

a. Weight. Older specifications such as MIL-F-8815 and MIL-F-24402 require that the filter remove a certain percentage by weight of a contaminant (usually glass beads of a specific size distribution). This test basically provides the efficiency of a new element and provides little information as to how the efficiency may change as the differential pressure across the element increases.

b. Size. In the past, many filter manufacturer's used a Nominal Rating to indicate filter performance. A 10 micron (micrometer) rating meant that the element removed a certain percentage (usually 90, 95 or 98 percent) of the particles larger than 10 micrometres. For nominal ratings to be of any use the percentage removal, the contaminant and the test procedure must be clearly defined. In most cases, this information was not provided.

c. Filtration Ratio (Beta Ratio). A numerical rating which is the ratio of particles greater than a given size flowing into a filter divided by the number of particles larger than the same size simultaneously leaving the filter. A Beta rating means that Air Cleaner (AC) fine test dust is the contaminant used for the test. If AC coarse test dust is used, the rating is identified as an Alpha Ratio. The test procedures generally employ automatic particle counters and allow the determination of the filter ratio for several different particle sizes as the differential pressure is increased to the terminal pressure. A $Beta_{10}$ = 50 means that for particles 10 micrometres and larger the upstream count is 50 times the downstream count. The Beta rating can be converted to an efficiency rating by the equation: Efficiency (%) = (1 - 1/Beta Ratio) x 100. Therefore, the filter with a $Beta_{10}$ = 50 will remove 98% of the AC fine test dust particles larger than 10 micrometres. The same filter element might have a $Beta_{5}$ = 10 meaning that the element will remove 90% of the AC particles greater than 5 micrometres.

556-7.4.1.2 Absolute Rating. The absolute rating is normally defined as the diameter of the largest hard spherical particle (usually a glass bead) which will pass through the filter medium under specified conditions. This rating is of minimum importance for hydraulic filters since elements with the same absolute rating may have significantly different efficiencies for removing system contamination.

556-7.4.1.3 Flow Rating. Flow rating is related to dirt capacity in that the amount of contaminant that an element can hold without exceeding a specific differential pressure is dependent upon the flow rate and the viscosity of the fluid. Filter elements are often rated based on MIL-H-5606 aircraft hydraulic fluid. The fluid used in ship hydraulic systems is often many times more viscous. When these elements are used in ship systems, the flow rating of the element must be downrated in proportion to the viscosity of the fluid in the system as compared to the viscosity of the fluid at which the element is rated. Table 556-7-2 and Table 556-7-3 show flow capacities of some aircraft filter elements when used in ship hydraulic system fluids at several different temperatures.

556-7.4.1.4 Dirt Capacity. Dirt capacity is a measure of the ″life″ of the element. Dirt capacity is an important factor in comparing elements of comparable filtration efficiency as it determines the frequency of maintenance and the related costs. In the past, many of the filter elements selected had an insufficient dirt capacity. If the elements in your system have a very short life, contact SEA 03W16 to see if an element with a greater dirt capacity can be used.

556-7.5 MILITARY SPECIFICATION FILTER HOUSINGS AND ELEMENTS

556-7.5.1 GENERAL. In the past many of the filters and filter elements selected for ship hydraulic systems had insufficient flow and dirt capacity and the logistic support costs for elements was very high. Military specifications have now been developed for interchangeable housings and elements specifically designed for ship hydraulic systems. MIL-F-24402 provides filter housings with high collapse pressure elements which can be used without bypass relief valves. MIL-F-24724 provides filter housings with bypass relief valves which use inexpensive low collapse pressure elements to MIL-F-24702/1. MIL-F-24702 is a general specification for elements and can be used to procure any configuration element by developing a specification sheet for that particular configuration element. Filter housings and elements to these specification and aircraft hydraulic filter elements and assemblies to MIL-F-5504 and MIL-F-8815 are discussed in the following paragraphs.

556-7.5.2 MIL-F-5504 FILTER ELEMENTS. These non-cleanable pleated paper elements provide good filtration at minimum cost. Filter elements conforming to MIL-F-5504 are stamped with the appropriate AN (Air Force-Navy Aeronautical Standard) number. See Table 556-7-2 for AN numbers and NSN's. Elements are non-cleanable but are not marked NON-CLEANABLE as this is the only type of element per MIL-F-5504.

Table 556-7-2. TYPICAL FLOW RATINGS FOR MIL-F-5504 ELEMENTS

	Rated Flow Capacity in Gal/Min						
Fluid Temperature	**MIL-H-5606**	**MIL-L-17672 MS2110-TH**		**MIL-L-17672 MS2135-TH**		**MIL-L-17331 MS2190-TEP**	
	37.8°C (100°F)	**21.1°C (70°F)**	**37.8°C (100°F)**	**21.1°C (70°F)**	**37.8°C (100°F)**	**21.1°C (70°F)**	**37.8°C (100°F)**
AN6236-1NSN-4330-00-252-0592	7-1/2	1-3/4	3-1/2	1-1/4	2-1/2	3/4	2
*AN6236-2NSN-4330-00-469-0811	15	3-1/2	7	2-1/2	5	1-1/2	4
AN6236-3NSN-4330-00-804-1541	30	7	14	5	10	3	8
AN6235-1ANSN-4330-00-028-6757	1/2	--	--	--	--	--	--
AN6235-2ANSN-4330-00-542-2060	3	3/4	1-1/2	1/2	1	1/4	3/4
AN6235-3ANSN-4330-00-203-3593	6	1-1/2	3	1	2	1/2	1-1/2
AN6235-4ANSN-4330-00-277-3274	12	3	6	2	4	1-1/4	3

* A stainless steel cleanable element (NSN-4330-00-064-8552) dimensionally equivalent to an AN6236-2 is available as a standard stock item.

Table 556-7-3. TYPICAL FLOW RATINGS FOR MIL-F-8815 ELEMENTS

	Rated Flow Capacity in Gal/Min						
Fluid	**MIL-H-5606**	**MIL-L-17672 MS2110-TH**		**MIL-L-17672 MS2135-TH**		**MIL-L-17331 MS2190-TEP**	
Fluid Temperature	**37.8°C (100°F)**	**21.1°C (70°F)**	**37.8°C (100°F)**	**21.1°C (70°F)**	**37.8°C (100°F)**	**21.1°C (70°F)**	**37.8°C (100°F)**
M8815/3-8 or MS28897-8*	6.0	1/2	1-1/2	1/3	1	--	1/2
M8815/3-10 or MS28897-10*	10.5	1	2-1/2	1/2	1-1/2	1/3	1
M8815/3-12 or MS28897-12*	16.0	2	4	1	3	1/2	2
M8815/3-16 orMS28897-16*	29.0	3	8	2	6	1	3
* See Table 556-7-4 for applicable filter assembly part numbers. The MS numbers are obsolete.							

556-7.5.2.1 Reservoir-Type (AN6236). These elements are often used for pump suction and transfer pump discharge filters, but can also be used in other low pressure applications. The elements are rated at ten micrometres nominal, have a 98 percent efficiency with 10 to 20 micrometre glass beads, and will withstand a maximum differential pressure of 75 lb/in^2 without permanent damage. These elements are available from the stock system in three lengths: approximately two inches (AN6236-1), four inches (AN6236-2), and eight inches (AN6236-3), all with a diameter of six inches. Two of the AN6236-1 types can be stacked to replace one AN6236-2 element, while two AN6236-2 elements can be stacked to replace one AN6236-3 type. An end gasket per AN6238-1, designed to seal each end unit and its mounting, should be inserted between elements when they are stacked in combination. All gaskets should be replaced when new filter elements are installed. In some applications a spacer is used between stacked elements, and a gasket is required on each side of the spacer. If spacers are missing, or additional spacers are required (as would be the case in changing from two AN6236-3 elements to four AN6236-2 elements), fabrication details and dimensions for the space can usually be obtained from the filter assembly drawings. As with all elements, the flow capacity of AN6236 elements will vary with the type of fluid used. Specification testing is conducted with MIL-H-5606 fluids at 37.8°C (100°F) and the rated flow. Table 556-7-2 compares rated flow capacities for new elements when used with other (shipboard) fluids and at two temperatures. Each of the conditions specified in Table 556-7-2 will result in a pressure drop of approximately one to two lb/in^2 differential across a clean element and approximately four to five lb/in^2 when dirt loaded. Flow rates higher than those indicated will result in a proportional increase in pressure drop.

556-7.5.2.2 Cleanable AN6236-2 Configuration Element. A cleanable element which is physically interchangeable with the AN6236-2 non-cleanable element is stocked in the Federal Supply System (NSN 4330-00-064-8552). This element has a 95 percent efficiency with 10 to 20 micrometre glass beads. Future stock under this NSN will be stamped CLEANABLE and INTERCHANGEABLE WITH AN6236-2.

556-7.5.2.3 Line-Type (AN6235). These elements have 95 percent efficiency with 10 to 20 micrometre glass beads and will withstand a differential pressure of 150 lb/in^2 . With ship hydraulic fluids, the elements have limited flow capacity which restricts their use to primarily hand pumps and applications with flow rates of 5 gal/min or less. For flow ratings with various fluids see Table 556-7-2. Elements conforming to MIL-F-8815/7, rated at five micrometre absolute and available in sizes dimensionally identical to AN6235 elements, can be substituted for AN6235 elements if necessary. The MIL-F-8815/7 elements are more expensive.

556-7.5.3 MIL-F-8815 FILTER ASSEMBLIES. These assemblies were originally intended for aircraft and missile hydraulic systems using MIL-H-5606 or MIL-H-83282 fluids. When used in ship hydraulic systems with more viscous fluids, the flow rating of the assemblies will be limited by the element capacity as indicated in Table 556-7-3. The standard military identification numbers (per MIL-F-8815) for some of the assemblies and elements are listed in Table 556-7-4. Many of the assemblies and most of the elements are stocked in the Federal Supply System under these numbers. However, many of the filter assemblies used aboard ship are not in complete compliance with the specification requirements. The weight requirement is usually deleted for shipboard units and consequently stainless steel and other materials are often used for the bodies in lieu of aluminum. A typical MIL-F-8815 bypass-type filter assembly is shown in Figure 556-7-1. The details of the open end of the element and the shutoff assembly are simplified to show functional operation. The internal O-rings of the shutoff assembly and the gland for the element O-ring are not shown because their location may vary with each manufacturer's particular design.

556-7.5.3.1 Automatic Shutoff for Bowl Removal. To prevent oil leakage out of the filter head when the bowl is removed, MIL-F-8815 filter housings are equipped with an automatic shutoff feature. If considerable leakage through the shutoff device is experienced in changing the element on these filters, it is possible that the internal

O-rings of the automatic shutoff device are damaged or missing. If so, the fluid may also be bypassing the element through the shutoff device after assembly. The filter assembly should be inspected if this condition is suspected.

WARNING

The automatic shutoff feature is spring-loaded and under considerable spring pressure. When disassembling the shutoff device to replace internal leaking seals, remove retaining screw (or any alternative capture element) with extreme care to avoid injury from flying parts. This particular maintenance action should be performed in the shop rather than while the filter assembly is installed in the system.

Table 556-7-4. MIL-F-8815 FILTER ASSEMBLIES

	Old Identification*		New Identification*	
Type	**Assembly**	**Element**	**Assembly**	**Element**
Bypass	MS28895–4	MS28897-8	M8815/1-4	M8815/3-8
	MS28895–6	MS28897-8	M8815/1-6	M8815/3-8
	MS28895–8	MS28897-8	M8815/1-8	M8815/3-8
	MS28895–10	MS28897-10	M8815/1-10	M8815/3-10
	MS28895–12	MS28897-12	M8815/1-12	M8815/3-12
	MS28895–16	MS28897-16	M8815/1-16	M8815/3-16
Nonbypass	MS28896-4	MS28897-8	M8815/2-4	M8815/3-8
	MS28896-6	MS28897-8	M8815/2-6	M8815/3-8
	MS28896-8	MS28897-8	M8815/2-8	M8815/3-8
	MS28896-10	MS28897-10	M8815/2-10	M8815/3-10
	MS28896-12	MS28897-12	M8815/2-12	M8815/3-12
	MS28896-16	MS28897-16	M8815/2-16	M8815/3-16
* The use of a C desigination after the dash number for either the assembly or the element indicates a cleanable element. The non-cleanable elements listed should be used for replacement.				

CAUTION

The shutoff device of MIL-F-8815 housings is constructed to withstand a maximum of 200 lb/in^2 . Do not apply system pressure when the bowl is removed.

556-7.5.3.2 Automatic Shutoff Diaphragm Seal Replacement. Because some of the seals on the automatic shutoff device (diaphragm) are not visible and difficult to replace, the following guidance is provided on repair criteria and procedures. There are three different sealing areas to be considered. The first area is the element O-ring, which is located in an accessible groove up in the diaphragm assembly. Whenever the element is replaced, this O-ring should be replaced in accordance with procedures for MIL-F-8815 filter assemblies given in paragraph 556-7.7.4. The second area of sealing is the filter bowl O-ring which is generally not visible when the bowl is removed. This seal does not require replacing unless oil is leaking from the bowl thread area during normal operation or from the diaphragm when the bowl is removed. The third area of sealing is the O-rings (generally two) internal to the diaphragm assembly. Leakage past these seals is hard to detect, but would show as fluid leaking from the diaphragm. With the bowl removed, a damaged bowl seal might also allow some oil to leak from the diaphragm. To replace the bowl seal and the internal seals requires disassembly of the shutoff device. This diaphragm is spring loaded and usually requires special tooling to facilitate safe disassembly (see Warning). The installed filter assembly should be removed from the piping to a bench area for disassembly.

556-7.5.3.3 Automatic Shutoff Diaphragm Disassembly. Before loosening the diaphragm capture screw, it is necessary to counteract the spring pressure behind the diaphragm. In an emergency, the spring pressure can be alleviated with C-clamps or with peripherally located blocks or a small sleeve in a vise. With the diaphragm spring compressed, it is possible by proper manipulation, to change the bowl O-ring and backup ring without unscrewing the capture screw. If the seals cannot be replaced without disassembly of the diaphragm assembly, carefully unscrew the diaphragm capture screw after the diaphragm spring has been externally compressed. When the screw has been removed, carefully and slowly unscrew the C-clamp or vise to allow the spring behind the diaphragm to be relaxed. When the diaphragm assembly is freed from the filter head, replace all O-rings and backup rings. When repair can be accomplished under routine maintenance conditions, a tool can be made to ensure a safer disassembly of the spring-loaded diaphragm assembly. The tool should resemble a threaded sleeve with one end conforming to the outside dimensions and thread of the filter bowl end. The tool should also be of sufficient thickness to butt the diaphragm assembly and retain the spring when the capture screw is removed. Carefully unscrew the tool to disassemble the diaphragm assembly.

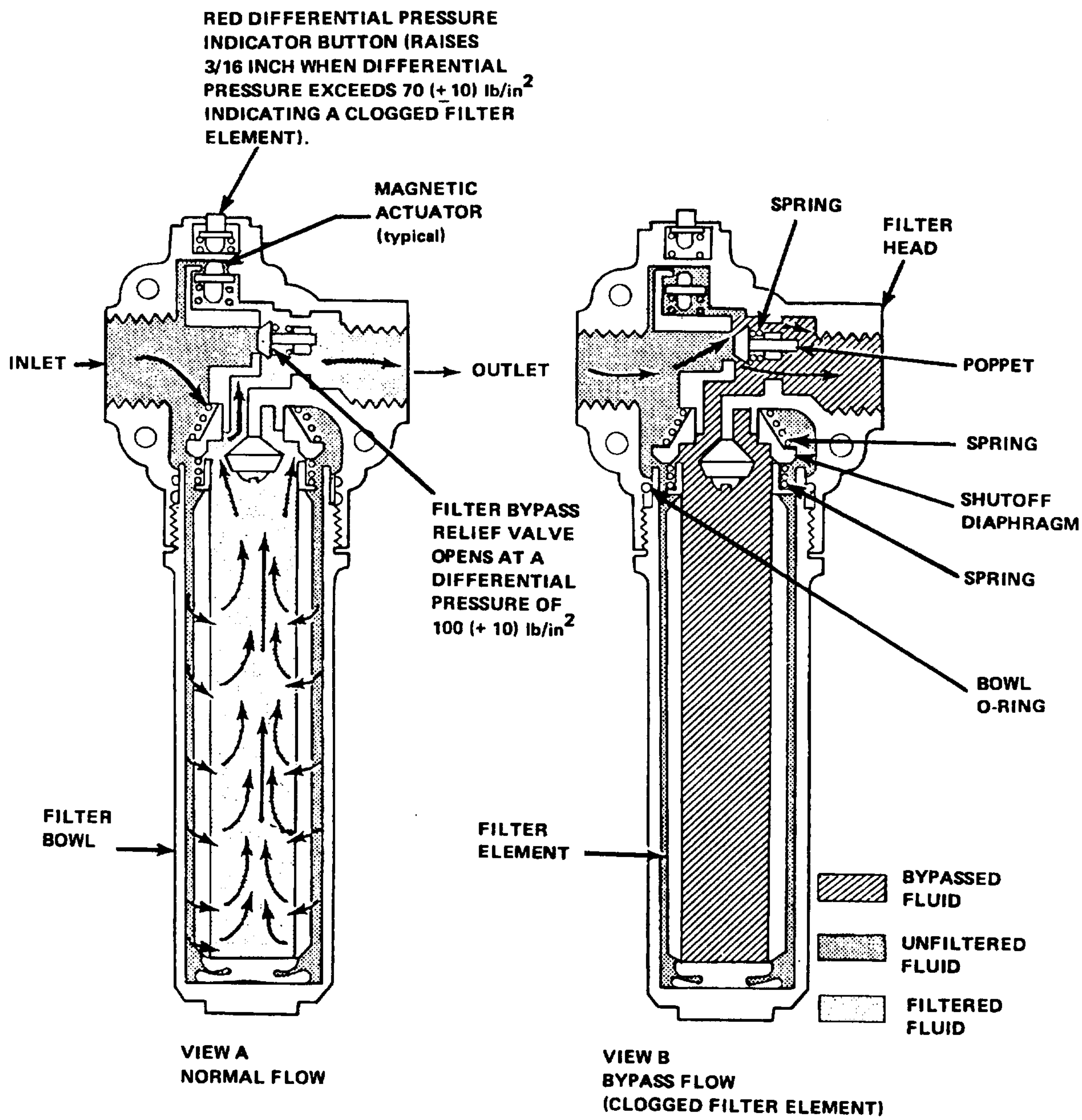


Figure 556-7-1 MIL-F-8815 Hydraulic Bypass - Type Filter Assembly

556-7.5.3.4 Plugging Bypass Relief Valves. As indicated in Table 556-7-4, MIL-F-8815, filter assemblies are available with and without bypass relief valves. Where system design permits, the use of filters without bypass reliefs is preferred. On submarines, many of the Aircraft Porous Media AD 3258 series of the dash 16 size have been converted from the bypass type to the nonbypass type. The modification kits, identified by Aircraft Porous Media part number AA- 3258-16D3Y34, are stocked under NSN 4330- 00-152-1349. The plugging assembly for APM 3258-16 filters is shown in Figure 556-7-2. The following plugging assembly installation sequence applies both to initial installation of the kit and any subsequent reassembly (refer to Figure 556-7-2 for part numbers called out in procedure):

1. Screw closure stud (1) and closure plug (2) together and install backup ring (3) and O-ring (4).

2. Wipe poppet and poppet relief port in filter to remove any accumulated dirt.

3. Lubricate contact surface between poppet and bypass closure stud with system fluid.

4. Install O-ring (6) and backup ring (5) on bypass closure plug.

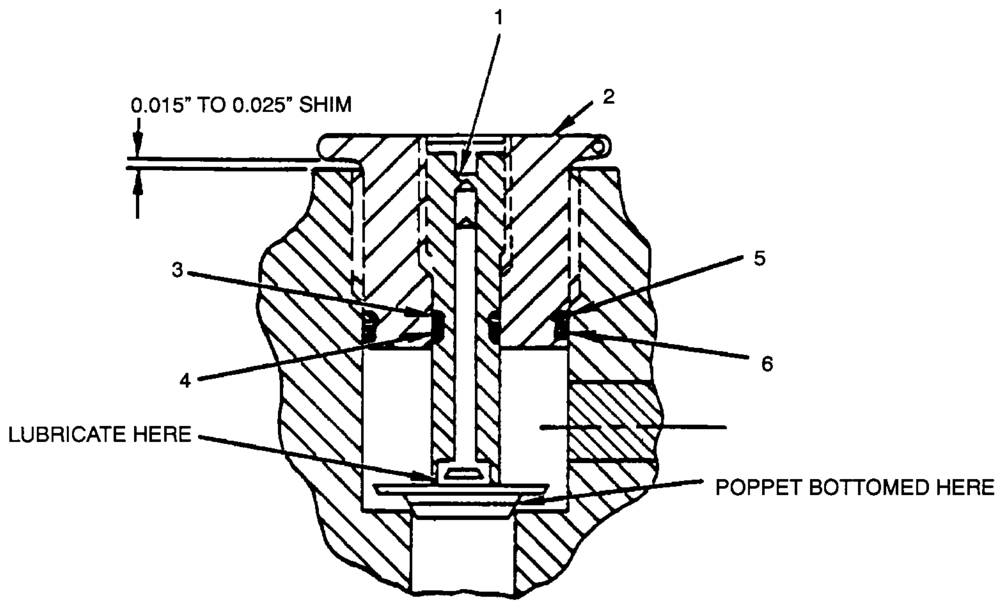
5. Position assembly over poppet so that poppet stem goes into machined space in bypass closure stud. Do not reinstall poppet spring.

6. Using a 0.015- to 0.025-inch shim between the plug and filter head, hand tighten the bypass closure plug. If the stud bottoms before the plug tightens on the shim, screw the stud out (counterclockwise) a few turns.

7. With the plug hand-tightened on the shim, screw the stud in (clockwise) until it bottoms the poppet against the filter head. Torque the stud lightly (5 to 10 in-lb) to ensure bottoming.

8. Remove the shim. Torque the plug from 12 to 14 ft-lbs, and lockwire per MS33540 using monel or stainless steel lockwire per MS20995.

9. With the plugging assembly installed, attach a label plate to the filter body which reads FILTER BYPASS VALVE PLUGGED.



ITEM	DESCRIPTION	SIZE	NSN
1	BYPASS CLOSURE STUD**		*
2	BYPASS CLOSURE PLUG		*
3	BACKUP RING	MS28774-010	5330-00-842-5505*
4	O-RING	M83248/1-010	5330-00-166-0969
5	BACKUP RING	MS28774-022	5330-00-841-9959
6	O-RING	M83248/1-022	5330-00-166-1011

* SUPPLIED WITH MODIFICATION KIT UNDER NSN 4330-00-152-1349
**TORQUE 5 TO 10 IN.-LB.

NOTE: ITEMS 5 AND 6 ARE NOT FURNISHED WITH THE KIT. THE BACKUP RING AND O-RING USED TO SEAL THE RELIEF VALVE PLUG IN THE ORIGINAL INSTALLATION ARE EQUIVALENT TO ITEMS 5 AND 6 AND MAY BE USED FOR THE MODIFICATION IF IN SATISFACTORY CONDITION. HOWEVER NEW RINGS ARE PREFERABLE

Figure 556-7-2 APM 3258-16 Filter Bypass Relief Valve Plugging Assembly

556-7.5.3.5 Deltadyne Differential Pressure Indicator Cleaning Procedure. The mechanical pop-up differential pressure indicator (Figure 556-7-3) is designed to actuate when the filter element is dirty and a differential pressure of 90 + 10 psi is developed across the element. The following steps explain how to disassemble, clean, and reassemble the differential pressure indicator.

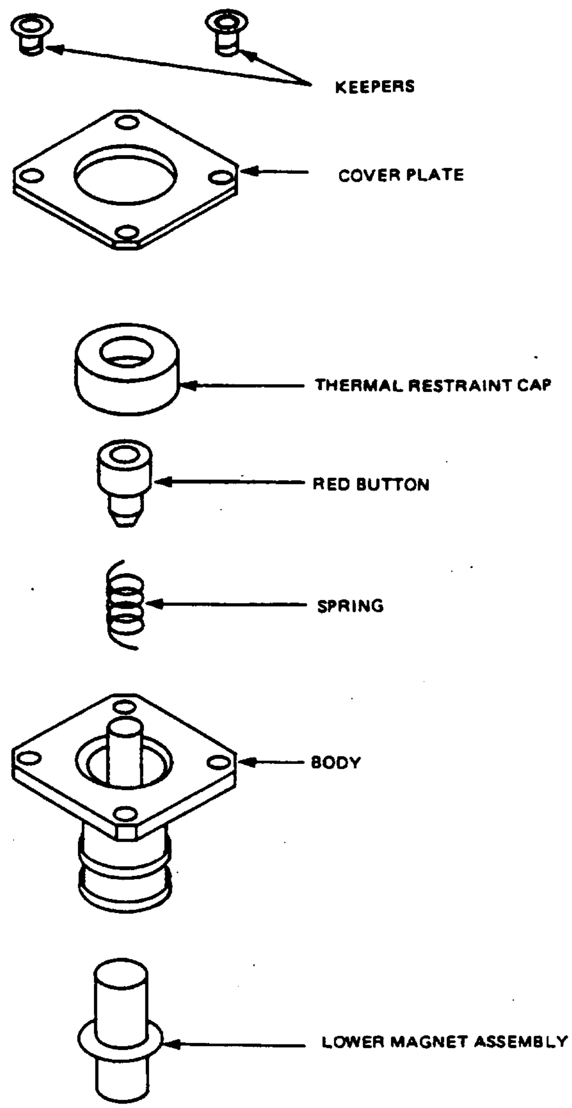


Figure 556-7-3 Deltadyne Differential Pressure Indicator

1. Removal and Disassembly of Pressure Indicator.
   a Remove lockwire from the bolt head and unscrew the four bolts.
   b Pull the Deltadyne pressure indicator out of the filter head.

CAUTION

Avoid damage to the O-rings.

   c Reset the pressure indicator by pushing both the lower magnet assembly and red button back into the body.
   d Using a machinist's scribe or easy-out, unscrew the two keepers.
   e Remove cover plate and thermal restraint cap.

CAUTION

The red button is spring-loaded. Be careful not to let the spring fly.

f Carefully pull the red button from the body.

g Pull the lower magnet assembly from the body.

h Remove the O-rings from the body.

2. Cleaning.

a Fill wash tank with 90 percent water and 10 percent water-soluble detergent (MIL-D-16792, type 1) solution that is available in one-gallon containers under NSN 7930-00-282-9699.

b Lightly scrub the body, actuator button, and thermal retention caps.

c Ultrasonically clean all the parts in the water-soluble detergent solution for 15 to 30 minutes.

d Rinse all parts with clean water to remove soap solution.

CAUTION

During reassembly, extreme care must be taken to prevent iron, or other magnetically attached materials from getting into the unit, as this could cause improper indicator operation and system contamination.

NOTE

Make sure parts are dry before reassembly.

3. Reassembly and Installation

a Place lower magnet assembly into body.

NOTE

Longer end of cylinder fits into body.

b Push spring and actuator button onto body.

c Center thermal resistant cap over actuator button.

d Install cover plate and screw in both keepers.

556-7.5.4 MIL-F-8815 FILTER ELEMENTS. Elements, per MIL-F-8815, are available with 5-micrometer and 15-micrometer absolute ratings. The filter elements used in ship hydraulic systems are, almost without exception, the 15-micrometre absolute configuration. The 15-micrometer absolute elements are available in cleanable and non-cleanable configurations while the 5-micrometre elements are non-cleanable. The MIL-F-8815/3 (15-micrometer absolute) and MIL-F-8815/6 (5-micrometer absolute) elements of the same dash size dimensionally are interchangeable and have a collapse pressure of 4500 lb/in^2 .

556-7.5.4.1 MIL-F-8815/3 (formerly MS28897) 15-Micrometer Elements. The filter elements are rated at 15 micrometres absolute and have an efficiency of at least 94 percent with APM F-9 glass beads. Flow capacity of the various dash size elements is dependent upon the fluid and fluid temperature as indicated in Table 556-7-3. These elements are used in the filter assemblies listed in Table 556-7-4. The NSN's for the elements are listed in Table 556-7-5. Non-cleanable elements are to MIL-F-8815/3 requirements which provide approximately three times the dirt capacity of the interchangeable cleanable elements. As indicated in Table 556-7-5 elements are available in interchangeable cleanable and non-cleanable configurations. Elements are marked CLEANABLE or NON-CLEANABLE to aid in identification in addition to the C suffix on the part numbers of cleanable elements.

Table 556-7-5 MIL-F-8815 FILTER ELEMENTS

Type	**Element Part Number**	**NSN**
Cleanable	MS28897-8C	1650-00-052-6592
Cleanable	MS28897-10C	1650-00-015-8887
Cleanable	MS28897-12C	4330-00-061-7906
Cleanable	MS28897-16C	1650-00-061-7836
Non-Cleanable	MS28897-8 or M8815/3-8	4330-00-761-2206
Non-Cleanable	MS28897-10 or M8815/3-10	4330-00-436-8238
Non-Cleanable	MS28897-12 of M8815/3-12	4330-00-042-6548
Non-Cleanable	MS28897-16 or M8815/3-16	4330-00-054-7791

556-7.5.4.2 MIL-F-8815/6 Elements. These elements are rated at five micrometres absolute and have a minimum efficiency of 97 percent when tested with a 50-50 mixture (by weight) of APM F-9 beads and AC fine test dust. These elements are available in the same dash sizes as the MIL-F-8815/3 elements. While normally used in MIL-F-8815/4 and MIL-F-8815/5 housings these elements will also fit the assemblies identified in Table 556-7-4. The five micrometre elements usually are not used in ship hydraulic systems and if substituted for the 15 micrometre elements may have a relatively short service life because of their higher efficiency.

556-7.5.5 MIL-F-24402 FILTER ASSEMBLIES. These filter assemblies designed for ship hydraulic systems are in accordance with MIL-F-24402 specification sheets /1, /2 and /3. The specification sheet number corresponds to the number of elements installed in the assembly. Since going to a specification sheet format, the part numbers for the assemblies have changed. See Table 556-7-6 for a cross reference between old and new part numbers. As used, housings to the old part numbers will no longer be stocked and replacement housings will be to the new part numbers. A Qualified Parts List (QPL-24402) should be consulted to identify filters by manufacturer's part numbers which are qualified to the specification. Parts with the same Military part number are interchangeable regardless of manufacturer. The housing part number consists of the Military Specification and slash sheet number followed by the letter N (no bypass relief) or R (bypass relief). Additional portions of the part number are described in later paragraphs for particular housings. All types (pop-up, gage, electrical) of MIL-F-24402 indicators are interchangeable in any filter housing. The indicator dash number is added to the housing part number for complete identification of the assembly. See Table 556-7-7 for indicator dash numbers.

Table 556-7-6 PART NUMBERS FOR MIL-F-24402 FILTER ASSEMBLIES

TYPE 1 ASSEMBLIES (Single Element)			
New part numbers		**Old part numbers**	
(Fatigue rated)[1]	**(Non-fatigue rated)**[1]	**(Fatigue rated)**[2]	**(Non-fatigue rated)**[2]
M24402/1NB	-	M24402-1N-BP-3	M24402-1N-BP-0
-	M24402/1NC	M24402-1N-CP-3	M24402-1N-CP-0
M24402/1RB	-	M24402-1R-BP-3	M24402-1R-BP-0
-	M24402/1RC	M24402-1R-CP-3	M24402-1R-CP-0
TYPE 2 ASSEMBLIES (Duplex - Two Elements with Selector Valve)			
New part number	Old part numbers		
(Fatigue rated)[1]	(Fatigue rated)[2]	(Non-fatigue rated)[2]	

Table 556-7-6 PART NUMBERS FOR MIL-F-24402 FILTER ASSEMBLIES

- Continued

TYPE 1 ASSEMBLIES (Single Element)			
New part numbers		**Old part numbers**	
(Fatigue rated)[1]	**(Non-fatigue rated)**[1]	**(Fatigue rated)**[2]	**(Non-fatigue rated)**[2]
M24402/2NS	M24402-2N-BF-3 Righthand outlet (rev. D and earlier)	M24402-2N-BF-0	
M24402/2NL	M24402-2N-BF-3 Lefthand outlet (rev. D and earlier)	M24402-2N-BF-0 Lefthand outlet (configuration not qualified but exists)	
M24402/2ND	M24402-2N-BF-3 (rev. D, amendment 1)	-	
M24402/2RS	M24402-2N-BF-3[1] Righthand outlet	M24402-2R-BF-0 Righthand outlet	
M24402/2RD	M24402-2R-BF-3 (rev. D, amendment 1)	-	
M24402/2RL	-	-	
TYPE 3 ASSEMBLIES (Three Elements)			
New part number[1]		Old part number[2]	
M24402/3NB	M24402-3N-BF-0		
M24402/3RB	M24402-3R-BF-0		

[1]If a differential pressure indicator is to be acquired with the assembly, add the appropriate indicator dash number suffix from MIL-F-24402/5 as shown in Table 556-7-7.

[2]Add E, G, or M depending on type of the differential pressure indicator acquired with the filter assembly. (See Table 566-7-7).

Table 556-7-7 PART NUMBERS FOR MIL-F-24402 DIFFERENTIAL PRESSURE INDICATORS

	New Part Number	**Old Part Number**	
Type	**(Fatigue Rated)**	**(Fatigue Rated)**	**(Non-fatigue Rated)**
Electrical(E)	M24402/5-E90 M24402/5-E45	M24402 Form E-3	M24402 Form E-0
Gage (G)	M24402/5-G150	M24402 Form G-3	M24402 Form G-0
Mechanical(M)	M24402/5-M90 M2440215-M45	M24402 Form M-3	M24402 Form M-0

556-7.5.5.1 MIL-F-244012/1 Filter Assemblies. These T-shaped assemblies are rated for pressures to 3000 psi and are available with (R) and without (N) bypass relief valves. The second letter (B or C) designates the size MIL-F-24402/4 element used. The assemblies with Size B elements are fatigue rated and suitable for flows up to at least 50 gpm with MIL-L-17331 and lower viscosity fluids. The assemblies with Size C elements are not fatigue rated and are suitable for flows up to at least 30 gpm with MIL-H-17672 and lower viscosity fluids. See Table 556-7-6 for a cross reference between new and old part numbers.

556-7.5.5.2 MIL-F-24402/2 Filter Assemblies. These duplex filter assemblies are fatigue rated at 3000 psi operating pressure and are equipped with a three-position selector valve that can direct flow through either or both elements. All the assemblies use MIL- F-24402/4 Size B elements. Each element can handle flows of at least 50 gpm with fluids as viscous as MIL-L-17331. The duplex assembly permits replacement of one element while directing flow through the other element. The first letter after the slash sheet designation indicates no bypass (N) installed or bypass relief (R) installed. The second letter indicates the outlet porting configuration: S-Standard right hand outlet port, L-Left hand outlet, D-Dual right and left hand outlet ports. The right and left outlet ports are generally installed for new construction. The dual outlet port is primarily for logistic support. However, the piping arrangement on some SSN 688 class submarines does not permit the installation of the dual outlet port assembly because of interferences. See Table 556-7-6 for a cross reference between old and new part numbers.

556-7.5.5.3 MIL-F-24402/3 Filter Assemblies. These three element assemblies have a maximum operating pressure of 400 psi and are used primarily in return lines with high flow rates. These units are rated at 150 gpm with 2190-TEP fluid per MIL-L-17331 and can accommodate even higher flows with less viscous fluids. In the part number, the first letter after the specification slash sheet number indicates bypass relief (R) installed or no (N) bypass relief installed. The second letter (B) indicates that the assemblies use MIL-F-24402/4 Size B elements. See Table 556-7-6 for a cross reference between old and new part numbers.

556-7.5.6 NONSTANDARD ASSEMBLIES WITH MIL-F-24402 ELEMENTS. There are a number of filter assemblies in service which use MIL-F-24402/4 filter elements but which do not comply with the configuration requirements for MIL-F-24402 assemblies. In general, if replacement is required, these assemblies should be replaced with the same assemblies. However, if the configuration is interchangeable with a MIL-F-24402 assembly then the MIL-F-24402 assembly can be considered for use.

556-7.5.6.1 MIL-F-24402/4 Filter Elements. These elements have a minimum efficiency of 97 percent with APM F-9 beads and provide performance comparable to MIL-F-8815 noncleanable elements rated at 15 micrometre absolute. The Beta10 rating is approximately 200. These elements have a very high dirt capacity and are reasonable in cost. The 4000 psi minimum collapse pressure of the elements permits their use in filter assemblies without bypass reliefs.

556-7.5.6.2 Element Sizes. The size designation for an element simply represents both the dimensional and performance requirements for the element as identified in MIL-F-24402/4. All the elements are designated as non-cleanable and are normally discarded after use. See paragraph 556-7.8 if cleaning is required in an emergency situation. Table 556-7-8 lists the flow rating and NSN's for the various size elements. With fluids less viscous than 2190-TEP, higher flow ratings may be permitted.

Table 556-7-8 MIL-F-24402 FILTER ELEMENT DATA

Size	**Style**	**NSN (4330-00-)**	**Rated Flow* (gal/min)**
A	N (Non-Cleanable)	483-0952	50
B	N (Non-Cleanable)	938-8044	50
C	N (Non-Cleanable)	483-0953	50
D	N (Non-Cleanable)	911-6596	20

*With 2190-TEP per MIL-L-17331 at 37.8°C (100°F)

556-7.5.6.3 Element Identification Marking. All MIL-F-24402 filter element are stamped with Military part identification number (PIN) and the word NON-CLEANABLE. The PIN will be in one of the following forms:

M24402 Style A (Very old), M24402 Size A (Old), and M24402/4 Size A (New) There are a number of proprietary elements which are interchangeable with MIL-F-24402 elements. Use of these elements is not recommended since they may have different performance characteristics such as lower collapse pressures. Only elements qualified to MIL-F-24402 can be marked with the MIL-F-24402 part identification number. For a listing of qualified elements, refer to QPL-24402.

556-7.6 FILTER DIFFERENTIAL PRESSURE INDICATORS

556-7.6.1 GENERAL TYPES. Mechanical pop-up indicators are used on many hydraulic system filter housings to indicate the need for element maintenance. These indicators actuate at specific differential pressures, and usually require manual resetting. Although they provide an indication of a dirty element, they give no feel for the rate at which dirt is being retained nor how dirty the element is. Another difficulty with indicators is that fluid pressure surges in the system can actuate them. Where continuous monitoring of the filter element life is desired, differential pressure gages are frequently installed on the filter housing. These gages are sometimes red-lined at various pressures, depending upon the application, to indicate the need for element replacement. In some installations, differential pressures must be obtained by subtracting the readings of two gages located somewhere along the filter inlet and outlet piping. Since these readings combine the pressure drops in the pipe line, filter housing, and filter element, it is important that periodic pressure drop readings on used elements be compared with initial clean pressure drop, at the same temperature and flow rate, to obtain a true increase in pressure caused by dirt entrainment. Because pressure drops may be much higher with a cold fluid due to increased viscosity, differential pressure gage and indicator readings across filter elements should be taken only after the system is up to operating temperature. See paragraph 556-7.5.3.5 for a cleaning procedure for mechanical pop-up indicators.

556-7.6.2 FILTER BYPASS INDICATORS. A filter bypass indicator, will provide a positive indication, when activated, that fluid is bypassing the filter element by flowing through the bypass relief valve. This indicator should not be confused with the pop-up differential pressure indicator previously discussed which simply monitors the pressure across the element. With the bypass indicator, a similar pop-up type button is often used to signal that maintenance is needed. However, the bypass indicators further signal that, as a result of the high differential pressures across the element, an internal bypass relief valve has lifted and some of the fluid is bypassing the element. If the situation goes unchecked, most of the fluid will eventually bypass the element. Identification of the type of installed indicator can be obtained from filter manifold drawings or related equipment manuals. In some filters, the flow paths created by the bypass condition can wash the collected dirt off the filter element and into downstream components. Both a fluid bypass indicator and a differential pressure indicator or gage, may be installed on the same filter assembly. When the bypass relief indicator actuates, elements should be changed as soon as possible because dirty fluid is bypassing the filter. However, maintenance action should be accomplished prior to bypass actuation if the installed differential pressure indicator or gage is working properly and proper maintenance procedures are being implemented. As with differential pressure indicators, bypass relief indicators can be activated by pressure surges, such as may be developed during cold starts or rapid system pressurization. On some relief indicators, the pop-up button, or whatever signal device is used, will return to a normal position when the surge passes and pressure is reduced. Other relief indicators may continue to indicate a bypass condition until manually reset. Before taking corrective action based on indicator readings, the bypass condition should be verified, at normal operating temperature and flow conditions, by attempting to reset the indicator.

556-7.6.3 MIL-F-24402/5 DIFFERENTIAL PRESSURE INDICATORS. The three types of differential pressure indicators covered by MIL-F-24402/5 are:

G - Gage type indicator

M - Mechanical pop-up indicator

E - Electrical with mechanical pop-up

The same porting gland is used to mount all three types of indicators and therefore, all types by all manufacturers are interchangeable. However, the indicators may require different length cap screws for installation. Therefore, replacement gages from the supply system include replacement cap screws of the proper length. In some installations, shipyards have installed protective shrouds around the gages and longer screws may be required for installation. Table 556-7-7 provides a cross reference of new and old MIL-F-24402 differential pressure indicator part numbers. Indicators with the suffix ″D″ in the part number have dual diameter bolt circles (4 holes each) for use with different diameter screws. (See paragraph 556-7.6.4.4) Table 556-7-9 provides a listing of mounting screws for the various indicators.

Table 556-7-9 MOUNTING SCREWS AND TORQUES FOR MIL-F-24402 TYPE DIFFERENTIAL PRESSURE INDICATORS

Manufacturer & Gage Part Number	**Screw Size**	**Screw Part Number**	**NSN**	**Torque (in-lbs)**
APM or PLM RD365, 366, 367, 371 or 351 Series**	#6-32 & Washer or #8-32	NAS1352-06H8P (1/2″ L) NAS1352-06H10P (5/8″ L) NAS620C6 NAS1352-08H8P (1/2″ L) NAS1352-08H10P (5/8″ L)	5305-00-182-9462 5306-01-030-9126 5310-00-773-7624 5305-00-731-9207 5305-00-731-9202	23 23 N/A 43 43
HR Textron 31-10063	#6-32	NAS1352-06H28P (1-3/4 L)	5305-00-680-7213	23
HR Textron 31-10090	#6-32 & Washer or #8-32	NAS1352-06H28P (1-3/4 L) NAS620C6 NAS1352-08H28P (1-3/4 L)	5305-00-680-7213 5310-00-773-7624 5306-00-832-1524	23 N/A 43
APM RD366BZ068	1/4-28	NAS1351-4H10P (5/8″ L)	5305-00-336-1124	55
HR Textron 31-10178	1/4-28	NAS1351-4H32P (2″ L)	5305-00-313-6195	55
M24402/5 Gages (See Table 556-7-7)	1/4-28	NAS1351-4H*P where * is length of screw in 16ths of an inch		55

**Applicable to gages with A, B, or C suffix on part number. Existing clearance holes in mounting flange for #6-32 screws may be drilled out for #8-32 screws. Gages with B suffix on part number use same fastener as APM RD366BZ068.

556-7.6.4 SELECTION OF INDICATOR TYPE. Some factors to be considered in selecting a particular type indicator are identified below. If you think the wrong type indicator is installed in an application, contact the NAVSEA LCM for a review of the selection. Mechanical Pop-Up Indicators

- Least Expensive
- Can be used where flow is infrequent or the flow rate varies significantly and monitoring with a gage type indicator is difficult
- May actuate prematurely during cold start-ups

Electrical Indicators

- Used where remote indication is required
- Subject to same use requirements as mechanical pop-up indicators

Gage Type Indicators

Suitable for applications in which temperatures vary significantly (correction charts may be required to determine the need for maintenance)

Provides an indication of how loaded the element has become

556-7.6.4.1 MIL-F-24402/5 Mechanical Pop-Up Indicators. Mechanical indicators are available with differential actuation pressures of 90 and 45 psi. To obtain maximum element life, the higher actuation pressure is recommended. However, in applications where it is necessary to limit the pressure, the lower actuation pressure indicator may be used. In a case drain line where the flow is low and there is a need to minimize the case drain pressure, the lower actuation pressure indicator can be used and the element life will be satisfactory because of the low flow rate.

556-7.6.4.2 MIL-F-24402/5 Electrical Indicators. The electrical indicators come with the same actuation pressures as the mechanical pop-up indicators since they also include mechanical indicators. The electrical switch is provided with a MS3102R-10SL-3P connection. The electrical rating on the single pole, double throw switch is 5A at 110 VAC, 28 VDC (resistive); 3A at 110 VAC, 28 VDC (inductive). The switch is constructed with a removable 2 watt, 6800 ohm resistor installed across the normally open contacts for possible use in a supervised monitoring system. The A and B pins (in accordance with MS33680) are connected to the normally open contacts.

556-7.6.4.3 MIL-F-24402/5-G150 Gage Type Indicators. The latest revision of the specification requires the gages to be accurate within plus or minus 11 psi for differential pressures within the 30 to 150 psi differential pressure range. Older gages had a range of 40 to 200 psi. The old and new gages can be used interchangeably and NSN 9Z6685-01-006-6043 applies. Actual gage range will vary depending upon manufacturer and when manufactured. The gages are not red-lined to indicate when element replacement is necessary since the differential pressure for element replacement can vary with each application. Operating pressure, flow rate, the type of fluid used and its operating temperature are all factors in selecting the pressure at which the element should be changed. Generally, change is not required until the element differential pressure exceeds 90 psi. Consult system technical manuals and PMS Maintenance Requirement Cards for guidance.

556-7.6.4.4 MIL-F-24402/5-G150D Gage Type Indicators. The ″D″ suffix at the end of the part number indicates that the gage is provided with a dual bolt circle mounting flange. It accommodates the standard four (1/4-28 UNF) mounting screws on a 1.1875 inch diameter bolt circle as well as four No. 6-32 or four No. 8-32 screws on a 1.069 inch diameter bolt circle. This will permit stocking of a single part for logistic support of both the standard MIL-F-24402 gage indicator and earlier indicators which used No. 6-32 and No. 8-32 mounting screws. This gage can then be used to support applications with any of the gage type indicators listed in Table 556-7-9. Currently the gages with 1/4 inch diameter mounting bolts are stocked under NSN 6685-01-006-6043 and gages which use the smaller screws for mounting are stocked under NSN 6685-00-127-6204. Continue to order under the applicable stock number.

556-7.6.4.5 Maintenance Guidance for MIL-F-24402 Differential Pressure Indicators. None of the indicators including the gage type are normally equipped for calibration adjustment. Therefore, the only maintenance that can normally be performed by forces afloat is replacement of leaking seals. All indicators use the same seals for the mounting gland. The recommended replacement seals are identified in Table 556-7-10. Seal problems usually result from the use of improper O-rings or the failure to use a back-up ring with the larger O-ring (located on the male gland of the indicator nearest the indicator body). The back-up ring is installed on the low pressure side of the larger O-ring; that is between the O-ring and the indicator body. The mounting screws and required torques are identified in Table 556-7-9. (See Warning)

WARNING

With the smaller No. 6-32 and 8-32 screws, use of the indicated screw and proper torquing is essential to prevent failure. Failure of these screws can result in a blown off indicator and high pressure fluid spray which are hazardous to personnel.

Table 556-7-10 MIL-F-24402 DIFFERENTIAL PRESSURE INDICATOR SEALS

Type Seal	Material	Location on Gage Male Gland	Specification and Size	NSN (5330-00-)
Back-up ring	Tetrafluorethylene	Nearest gage	MIL-R-8791/1-015	
O-ring	Fluorocarbon rubber	Gland nearest gage	MIL-R-83248, M83248/1-015	166-0991
O-ring	Fluorocarbon rubber	Furthest from gage	MIL-R-83248, M83248/1-014	166-0990

556-7.6.5 MIL-F-24724 FILTER ASSEMBLIES. These filter assemblies, rated at 3000 psi are equipped with bypass relief valves and utilize low collapse pressure elements per MIL-F-24702/1. Each assembly is equipped with a differential pressure indicator which is connected to the relief valve operator to indicate when element replacement action is necessary. The differential pressure indicators (both mechanical and electrical) have a tricolor (green, yellow, red) scale to indicate filter condition. The colors represent the following conditions:

With the electrical indicator, a switch is also actuated when the bypass relief opens, in order to send a signal to a remote light or alarm. The standard bypass relief setting is 50 psi although some assemblies are available with 25 psi settings. See QPL-24724 for a listing of qualified assemblies. Assemblies of different manufacturers are interchangeable.

Color	Bypass-Relief	Element
Green	Closed	Clean
Yellow	Closed	Becoming loaded
Red	Open	Clogged (change)

556-7.6.5.1 MIL-F-24724/1 Filter Assemblies. These assemblies contain 1, 2 or 3 MIL-F-24702/1 elements depending upon their flow rating (30, 60 and 90 gpm). When multiple elements are used they must be connected with a MIL-F-24702/1 element connector. The dash number following the M24702/1 designation indicates the number of elements installed. The element connector is normally reused when changing elements unless damaged. To change elements, the filter must be isolated or the system shut down and depressurized. Since there is a cap on the end of the filter canister (bowl) which is at the highest level, the loss of fluid is minimized.

556-7.6.5.2 MIL-F-24724/2 Filter Assemblies. These assemblies are similar to the /1 assemblies above except that they contain two canisters (bowls) for elements, each of which contains 2 or 3 elements depending upon the flow rating (120 and 180 gpm). The ″4E″ and ″6E″ dash numbers in the part number indicate the number of elements in the assembly. This general specification can be adapted to any configuration element by the generation of a specification sheet. To date, the only configuration element covered is MIL-F-24702/1. The same configuration element with a 150 psi collapse pressure is available in two filtration ratings. The part numbers and NSN's are:

The Beta10 element provides a filtration ratio of 75 for particles larger than 10 micrometres when tested with AC fine test dust. The Beta5 element provides a filtration ratio of 25 for particles larger than 5 micrometres with AC fine test dust. (See paragraph 556-7.4.1.1 for an explanation of Beta ratios.) The B10-75 element is currently being used to support all applications because the difference in efficiency between the two elements is not great and only one source is qualified for the B5-25 element.

Part Number	Flow Rating	National Stock Number
M24702/1-B10-75	30 gpm	4330-00-229-4147
M24702/1-B5-25	20 gpm	(Not yet assigned)

556-7.7 FILTER ELEMENT MAINTENANCE

556-7.7.1 ELEMENT HANDLING. In spite of a sometimes rugged appearance, filter elements are delicate and should be handled with the same care as would be given to a watch or a light bulb. Element life can be ended prematurely by physical damage to the filtering media. In this case, differential pressure readings may remain low indefinitely, since dirt may pass through the element without being retained. Once installed, a severely damaged element may show no need for replacement. Therefore, an element which exhibits any indication of physical damage should be thoroughly inspected before installation (see paragraph 556-7.8.3).

556-7.7.2 ELEMENT REPLACEMENT. Maintenance should be conducted in accordance with the procedure specified in the Planned Maintenance System (PMS) MRC's or in the appropriate equipment instruction book. Frequently this procedure is based upon readings from differential pressure gages and indicators which are installed on the filter assembly. When differential pressure gages reach the red-line pressure (or some other pressure specified by the maintenance system as requiring corrective action) or when differential pressure indicators are activated, a small percentage (10 to 20 percent) of the original dirt capacity usually remains. If gages or indicators have been removed, or are inoperative, and there are no filter bypass relief valves, excessively dirty elements will eventually become apparent from either reduced fluid flow or reduced system pressure downstream, caused by the clogged filters. If filter bypass relief valves are installed, dirty fluid can continually bypass the filters once the dirt retained by the elements increases the differential pressure sufficiently to cause the reliefs to open. Therefore when gages or indicators are not installed or are inoperative, elements must be cleaned or replaced regularly to ensure system cleanliness. If no maintenance guidance is available, and the filter housing is the type without visual indication of the condition of the element, it is recommended that the element be inspected and cleaned or replaced as necessary, after approximately 20 hours of system operation when the equipment is new or has been opened for repair or adjustment. If the first inspection shows little loading, the checks may be extended to 100 hours, then 200 hours, and finally a maximum of 500 hours of operation, or a time interval of no more than three months, whichever occurs first. If filter dirt loading is heavy at any inspection, the frequency of maintenance should be adjusted as necessary. Since dirt loading of an element is not usually readily apparent from visual inspection, particular attention should be given to the occurrence of system component failures or malfunctions which may be the result of a dirty fluid.

556-7.7.3 ELEMENT SELECTION. Shipboard filter elements may be of either the cleanable or non-cleanable (disposable) type, and are usually stamped accordingly. An element that is not stamped cleanable should be assumed to be non-cleanable, and not cleaned and reused until identification can be obtained. When both cleanable and non-cleanable elements are available to fit a system filter housing, it is recommended that non-cleanable elements be used. For critical systems, one set of cleanable elements, if available, should be carried as spares in case logistic support of the non-cleanable elements can not be maintained.

556-7.7.4 REMOVAL AND INSTALLATION PROCEDURES. Generally, installation of filter elements is a simple matter. Once the filter manifold has been isolated and depressurized, access to the element is usually attained by unscrewing a filter bowl, an element retaining nut (SSN 637 Class and SSBN 640 Class pump discharge filters), or a filter housing cover (many return line filters). Elements are usually held in place by an O-ring on the open end of the element, and sometimes spring pressure is applied on the closed end of the element. Elements should be carefully pulled out of the housing to avoid damaging the O-ring, the O-ring groove, or the mated sealing surface. On MIL-F-8815 filter housings and housings which use MIL-F-24402 size A and D elements, the O-ring which seals against the element is located in the filter head. With MIL-F-24402 size B and size C elements, the O-ring is located on the element. Note that the O-ring on the size C is on the inside surface of the element inlet. A good seal between the element and the filter housing is essential to satisfactory performance. Therefore, the O-rings should be replaced, or at least inspected for cuts or other damage, each time an element is changed. O-ring identification and ordering information is provided in Table 556-7-11 for MIL-F-8815 and MIL-F-24402 filter elements. To facilitate element removal and reduce housekeeping, some filter housings and filter bowls are provided with drain plugs. In general, the oil drained from any filter during element installation is contaminated and should not be returned to the hydraulic system. Oil remaining in filter bowls can also be expected to be highly contaminated. Filter bowls should be emptied of oil and cleaned before reassembly. For bowls which use MIL-F-24402 size A elements, special care is necessary to avoid losing the spring which may remain in the bowl if not removed with the element. Most size A element installations are provided with a small spring which fits into a recess which holds it in place in the bottom of the element.

CAUTION

When repressurizing filter housings after maintenance, open valves slowly and carefully. Avoid rapid compression, as any trapped air represents an explosion hazard. Prior to pressurizing, add clean oil to filter bowls and have filter housing vents open to minimize the amount of trapped air.

Table 556-7-11 O-RINGS SEALS FOR INSTALLING ELEMENTS

Filter Specification	**Filter Elements**	**O-Ring Specification and Size**	**NSN (5330-00-)**
MIL-F-8815	M8815/3-8*	MIL-R-83248, M83248/1-018	166-0994
MIL-F-8815	M8815/3-10*	MIL-R-83248, M83248/1-020	166-1001
MIL-F-8815	M8815/3-12*	MIL-R-83248, M83248/1-024	166-1020
MIL-F-8815	MS8815/3-16*	MIL-R-83248, M83248/1-028	166-1030
MIL-F-24402	Size A*	MIL-R-83248, M83248/1-132	167-5120
MIL-F-24402	Size B	MIL-R-83248, M83248/1-224	166-8422
MIL-F-24402	Size C	MIL-R-83248, M83248/1-132	167-5120
MIL-F-24402	Size D*	MIL-R-83248, M83248/1-028	166-1030

*O-ring is installed in filter housings.

556-7.8 FILTER ELEMENT CLEANING

556-7.8.1 GENERAL GUIDANCE. Cleanable filter elements do not last forever. Each successive cleaning usually removes less and less of the retained contaminants. Filter elements, which are constructed of a depth-type media are generally more difficult to clean than screen-type filters and strainers. Ultrasonic cleaners, installed on many ships, provide an effective all-around cleaning capability. However, non-cleanable elements must not be ultrasonically cleaned, as resulting degradation of element media will subsequently contaminate the hydraulic system. In an emergency, most non-cleanable elements may be back flushed, rinsed, and dried. Cleanable reusable elements should be individually bagged or wrapped in Saran Wrap or other plastic type material to keep them clean until needed. Clean cloths, or original packing box, will provide some protection from physical damage.

556-7.8.2 RECOMMENDED PROCEDURE. The following procedure will effectively clean many depth-type cleanable elements to a high percentage of new life when filter elements have been used in a normal manner and removed for cleaning before the differential pressure becomes excessive. This procedure is intended for elements through which the normal fluid flow is from outside to inside. Strainers may be cleaned using only an ultrasonic cleaner.

NOTE

Prior to cleaning, O-rings shall be removed from the element. Exceptionally dirty or greasy elements should be soaked and agitated in a water-soluble detergent solution to improve the effectiveness of the cleaning procedure.

1. Fill the element cavity with a 90 percent water, 10 percent water-soluble detergent (MIL-D-16791, type 1) solution available in one gallon containers under NSN 7930-00-282-9699. Full strength commercial detergents such as Joy, Amway L.O.C. (biodegradable), or equivalent detergents may be used in equal parts with water if the specification detergent is not available.
2. Using filtered shop air (MIL-F-8815, 15 micrometre filter, or equivalent) supplied through a hose, nozzle, and a one-hole rubber stopper which has been inserted into the end of the element, reverse flush the element with air, forcing the liquid out through the filter surface.
3. Rinse element with clean water to remove soap bubbles.
4. Repeat steps 1, 2, and 3 using clean water instead of detergent, until the rinse water is clear and all traces of detergent have been removed.
5. Repeat steps 1 through 4 if necessary.

NOTE

Step 6 is optional-recommended for excessively dirty filters.

6. Clean element ultrasonically in a water-soluble detergent for 15 to 30 minutes and repeat step 4. Complete removal of detergent before ultrasonic cleaning of elements is not necessary.
7. Oven dry the filter element at 54°C (130°F) to 66°C (150°F).

CAUTION

Scrubbing filter elements with a brush is not recommended because it is ineffective and may damage the element.

556-7.8.3 INSPECTION. After cleaning, filter elements should be inspected for nicks, dents, and other signs of physical damage. Usually, elements with obvious damage contain large holes, are ineffective as filters, and should be rejected. Elements should be bubble-point tested before reuse to identify any element damage or deterioration (see paragraph 556-7.8.4). However, many ships do not have this capability, and must rely solely upon visual inspection to determine element acceptability. If possible, damaged elements should not be used until bubble points can be performed and a satisfactory condition can be confirmed. Forces afloat can determine the effectiveness of element cleaning, to some extent, by observing the differential pressure gages installed on the filter housings. If the gage indicates a high pressure drop (generally a value approaching the red line) upon installation of a cleaned element in a system operating at normal temperatures, the element probably has been saturated with dirt beyond practical restoration limits, and it should be discarded.

556-7.8.4 BUBBLE POINT TESTING. Bubble points are relatively simple to determine and take only a few minutes. Often the bubble point tester is included in the same console as the ultrasonic cleaner. Detailed operating instructions are provided in the operator's manual supplied with the equipment. In bubble point testing, the element is connected to a low pressure air supply and immersed in isopropyl alcohol or equivalent fluid at 21°C ± 3°C (70°F ± 5°). The fluid level is maintained about one-half inch above the top of the element. The air pressure, indicated in inches of water by a manometer, is slowly raised in small increments. The element is rotated 360 degrees about its longitudinal axis at each increment of air pressure so that the entire filter area can be observed for the appearance of the first bubble. The bubble point is that pressure, usually expressed in inches of water, at which the first air bubble emerges from the filter surface of the element being tested. The bubble point is directly related to the porosity (hole size) of the filter; that is, larger holes result in lower bubble point value. New filter elements to MIL-F-24402 will have bubble points generally between four and nine inches of water, depending upon which manufacturer made the element. Bubble points below the original value indicate element deterioration, an increase in maximum pore size, and a loss of filtration effectiveness. Elements (regardless of manufacturer) which test out less than two inches of water should be discarded. This criteria is not applicable to coarse screen filters and strainers, which have holes large enough to see through and therefore have very low bubble points even when new.

SECTION 8.

MAINTENANCE

556-8.1 PREVENTIVE MAINTENANCE

556-8.1.1 With the Planned Maintenance System (PMS) installed, preventive maintenance shall be conducted in accordance with the Maintenance Requirement Cards (MRC's).

556-8.2 HYDRAULIC SYSTEM CONTAMINATION

556-8.2.1 During installation, maintenance, and repair, the retention of cleanliness of the system is of paramount importance for subsequent satisfactory performance. All openings which are not required for access should be kept closed with blanks or stoppers. Work should be conducted in the cleanest possible environment. New parts should be clean before installation. Further, similar precautions should be observed when setting up any part of the system for shop tests and conducting such tests. Any temporary piping or fittings used for such tests should be free from contamination.

a. Any extraneous material found in a hydraulic system may be considered a contaminant. Contaminants may be solids, liquids, or gases. No system is completely free of contamination. Satisfactory operation of hydraulic equipment depends mainly upon keeping the contaminants down to levels which do not adversely affect the equipment.

b. Solid contaminants may be material introduced into the system from outside or it may be generated within the equipment. Erosion, corrosion, and wear are continually occurring in a hydraulic system. The contamination being generated is flushed away with the fluid and is either trapped in the system filter, settles in a low spot in the system, or finds its way into a vital spot where it may cause damage or a malfunction. Besides the particles being generated in a system there is a continuing release of contaminants from the surfaces of castings, tubing, and welded assemblies. Contamination entering the system from outside may get into the system in various ways. It may be in the fluid when the system is filled, it may get in through open vents or missing filler caps, or it may enter by working past seals and packings. Hard metallic or silica contaminants are damaging to rubbing and rolling surfaces. Organic materials such as lint, cork, asbestos, and rubber may cause sticking valves or plugged orifices. Both types must be avoided and reduced to the maximum extent practical.

c. The most common liquid contaminant in hydraulic systems is water. In a shipboard environment it can be very easy for water to get into a system. Other liquid contaminants could include a variety of conceivable fluids which might be accidently introduced. The liquid contaminants may accelerate corrosion and wear in the system, or they may attack certain materials used in the equipment. These contaminants may also form sludges or other insolubles, or give faulty system response.

d. Gaseous contamination normally is not a significant problem. Extraneous gases that are entrained in the fluid which is added to a system, or that form in the system, will generally work out of the fluid and be carried away by the aspiration of the air in the reservoir. Excessive gases can form sufficient quantities of foam to cause operational problems, but in general Navy fluids and systems are designed to eliminate foaming problems.

556-8.3 HYDRAULIC FLUID CONTAMINATION

556-8.3.1 GENERAL. The condition of a hydraulic system, as well as an indication of future system performance, can be best determined by analyzing the operating fluid. Of particular interest are degradation of the physical and chemical properties of the fluid, excessive particulate contamination, and excessive water contamination, any of which indicate impending trouble. In general, hydraulic fluids are selected for each application so that minimum fluid degradation will occur, filters are installed to keep particulates down to acceptable levels, and systems are designed and constructed to minimize the possibility of water contamination. Allowable use limits identify the extent that chemical or physical properties of a particular hydraulic fluid may degrade during use before replacement or reclamation is required. Table 556-8-1 identifies the use limits that shall be used for naval ship hydraulic systems unless specific requirements have been established for a particular system. Requirements for allowable solid and water contamination levels for Gun and Missile Launcher Ordnance Hydraulic Systems is contained in NAVSEA SW323-AC-MMA-010. For additional information on hydraulic fluids, refer to NSTM Chapter 262, Lubricating Oils, Greases, and Specialty Lubricants and Lubricating Systems. Requirements for allowable solid and water contamination levels for submarine hydraulic systems are contained in paragraph 556-8.6.

Table 556-8-1 ALLOWABLE USE LIMITS OF HYDRAULIC FLUIDS[6]

	Fluid Type						**Test Procedure**
	MIL-F-17111	**MIL-H-19457**	**MIL-H-5606**	**MIL-H-6083**	**MIL-H-17672**	**MIL-L-17331**	
Min Flash Point,°C (°F)	104.4(220)	246.1(475)	93.3(200)	93.3(200)			ASTM D92

Table 556-8-1 ALLOWABLE USE LIMITS OF HYDRAULIC FLUIDS[6] - Continued

	Fluid Type						**Test Procedure**
	MIL-F-17111	**MIL-H-19457**	**MIL-H-5606**	**MIL-H-6083**	**MIL-H-17672**	**MIL-L-17331**	
Water Content, % Max., Water Content, % Max.,	0.05	0.3	0.05	0.1	0.05	0.05	ASTM D95 ASTM D1744
Viscosity, centistokes at 40°C (104°F) Min.	23		9	9	(2135TH) 55 (2110TH) 37 (2075TH) 26	70	ASTM D445
Acid No., mg KOH/gram Max.			0.2				ASTM D664
Acid No., mg KOH/gram Max.		0.3					Fed. Std. 791 Method 5102
Neutralization No. Max.	0.3				0.5	0.5	ASTM D974
RBOT, minutes (minimum)						75	ASTM D2272
Solid Particles Mg/ 100 mL Max.	8.0 (unless otherwise specified)	8.0	8.0	8.0	8.0	8.0	NFPA T2.9.14
Hydrocarbon Oil Contamination, % Max.		2.0					Specific Gravity

Applicable tests and their frequency should be identified on system Maintenance Requirement Cards (MRC’s). If MCR’s do not provide this information, request that they be revised. However, samples may be taken and appropriate tests requested any time fluid problems are suspected.

Prior to submitting fluids for water testing per the ASTM procedures, testing per the simple field procedures in paragraphs 556-8.7.1.1 and 556-8.7.1.2 is recommended.

Determine as follows: Make known mixtures of the suspected hydrocarbon oil contaminant and new MIL-H-19457 fluid: measure specific gravity of these mixtures. Prepare a graph of these specific gravities and use to estimate the oil content of the used MIL-H-19457 fluid.

Acceptable use limits have not yet been established for MIL-H-22072 fluids for ship hydraulic system applications. If operational difficulties with systems using these fluids are suspected to be fluid-related, or if the fluid is otherwise suspected to be unsatisfactory, NAVSEA should be advised of the problem and requested to supply latest use data available on these fluids.

Before performing the ASTM D95, conduct the ″Crackle″ test described in paragraph 556-8.7.1.2. If the fluid passes the ″crackle″ test, the ASTM D95 test is not required.

For fluids not covered in this table, the use limits in NSTM 262, Table 262-9 are applicable.

To make on-site viscosity measurements, see paragraph 556-5.6.7.1.

See Table 556-8-4 and Table 556-8-5 for submarine hydraulic system fluid solid and water contamination limits.

When acceptable particulate and water limits have been exceeded, economy and ecology are usually best served by making an effort to remove the solids and water rather than replacing and discarding the old fluid.

556-8.3.2 FLUID DEGRADATION. Degradation of the fluid is usually attributed to unnatural circumstances, such as operating at abnormally high temperatures or adding an incompatible fluid to the system. Degradation is generally irreversible, as compared to water contamination and particulate contamination, which can be mechanically removed. When degradation to, or beyond, the safe use limit occurs, the oil or fluid should be cleaned or replaced as soon as possible. Fire resistant hydraulic fluid conforming to MIL-H-19457 that has reached the use limit shall not be replaced without the concurrence of NAVSEA.

556-8.3.3 PARTICULATE CONTAMINATION LIMITS. Excessive particulate contamination of the fluid indicates that the filters are not keeping the system clean. This can result from improper filter maintenance, inadequate filters, or excessive ongoing corrosion and wear due to fluid degradation, water contamination, and particulate contamination. Because of the wide variance in hydraulic systems, no single contamination requirement can be imposed for all systems. Although cleaner systems perform better, increasing cleanness requires greater expenditures of time and money. The level of cleanness that should be specified and attained is that level which will ensure satisfactory system performance. Contamination levels of fluids, systems, or components are determined primarily by either counting or weighing the particles. Correlation between the two techniques is difficult. Automatic particle counting is the preferred method.

a. When particle counts are used to quantify contamination, they can be identified with ISO 4406 scale numbers as identified in Table 556-8-2. These scale numbers can be used to describe a wide range of contamination levels. The ISO (International Organization for Standardization) 4406 Cleanliness Code is the most descriptive method of classifying system cleanliness. It is easy to fit the particle count data from operating hydraulic system fluid samples to the specified ISO codes.

Table 556-8-2 ISO 4406 SCALE NUMBERS

ISO 4406 Scale Number	**Number of Particles Per Millilitre**	
	More than	**Up to and including**
26	320,000	640,000
25	160,000	320,000
24	80,000	160,000
23	40,000	80,000
22	20,000	40,000
21	10,000	20,000
20	5,000	10,000
19	2,500	5,000
18	1,300	2,500
17	640	1,300
16	320	640
15	160	320
14	80	160
13	40	80
12	20	40
11	10	20
10	5	10
9	2.5	5
8	1.3	2.5
7	0.64	1.3
6	0.32	0.64
5	0.16	0.32
4	0.08	0.16

Table 556-8-2 ISO 4406 SCALE NUMBERS - Continued

ISO 4406 Scale Number	**Number of Particles Per Millilitre**	
	More than	**Up to and including**
3	0.04	0.08
2	0.02	0.04
1	0.01	0.02

b. The ISO code corresponding to a contamination level permits the differentiation of the dimension and distribution of particles. ISO 4406 designates two scale numbers that are combined to create the system cleanliness level classification. The scale numbers are attributed according to the number of particles counted equal to or greater than 5 micrometer (mm) and 15 micrometer (mm) respectively, per 1 milliliter (mL) of fluid (see Table 556-8-2). The first scale number defines the number of 5 micrometre (mm) and larger particles in 1 (one) milliliter of fluid, which is an indication of silting tendency of the system. The second number in the code system defines the number of particles 15 micrometer (mm) and larger, which is an indication of the number of wear particles in the system. The contamination level code is then established by writing two scale numbers one after the other and separated by an oblique stroke (slash). For example, A code number of 18/13 signifies that there are between 1300 and 2500 particles equal to or larger than 5 mm, and between 40 and 80 particles equal to or larger than 15 mm in 1 milliliter (mL) of a given fluid sample. The scale numbers are as defined in Table 556-8-2. The ISO cleanliness code can also be portrayed as a graphical representation of the ISO code system overlaid on a log-log^2 graph which is suited for direct reading and plotting of particle count data and yields a straight line approximation for most data.

c. When contaminants are weighed to determine the contaminant level, the technique is referred to as a gravimetric analysis method. Gravimetric analysis measures the weight of solid contaminants present in a specific volume of fluid. It is accomplished according to the procedures of NFPA T2.9.14, ″Hydraulic fluid power - Fluid contamination - Determination of solid contaminant level by the gravimetric method.″ In this method, a known volume of sample fluid, normally 100 milliliter (mL), is passed through two preweighed membrane filter discs of 47 mm diameter and 0.8 micrometer pore sized, made of material compatible with the sample fluid and solvent used in rinsing the apparatus. Gravimetric analysis is easy to perform and is reproducible. However, it does not provide as much information as does particle counts, and is, therefore, the less preferred of the two, particularly when the contaminant levels are low. However, the gravimetric method is quite useful for monitoring flushing operation or analyzing grossly contaminated samples which are difficult to analyze with the particle count method. As with particle counts, the tolerable weight of particulates is dependent upon the individual system.

d. If the particulate contamination in hydraulic system exceeds the specified requirement, circulating the fluid through system filters should clean the fluid. If system filters are lacking, or otherwise unsuitable for a major clean-up, portable filters should be hooked into the system. Portable filtering units, with a pump, micronic filter, and connecting hoses, should be available from a shipyard, repair facility, or tender. If filtering can not be accomplished, some relief can be obtained by draining the contaminated fluid immediately after system operation while the fluid is still hot and dirt is in suspension, hand cleaning accessible areas, and filling the system with new clean fluid. Several repeats of the circulate, drain, and fill cycle may be required to achieve the desired cleanness. Fluid replacement because of excessive particulates is recommended only as a temporary fix. Filters should be procured or put in working order as soon as possible to preclude the need for future fluid replacement.

556-8.3.4 WATER CONTAMINATION LIMITS. The presence of water in hydraulic fluid generally comes from condensation in vented reservoirs, failure of piping or components at water-oil interfaces (such as coolers or hull penetrations), or taking on water-contaminated oil as a result of filling systems during rainstorms, or improper drum storage. Sealed oil drums which are stored out of doors in a vertical position with bungs up breathe with changes in temperature, and on cooling each night will suck in any water that may have accumulated on the top of the drum or the moisture-laden air. MIL-HDBK-201 provides guidance for proper storage of oil containers. Although it is preferable to have no water in the oil, some water content is inevitable. For example, new oils conforming to MIL-L-17331 and MIL-L-17672 generally contain 40 to 80 ppm (0.004 to 0.008 percent) water. Saturation values for some MIL-L-17331 (2190 TEP) oils have been measured as 130 to 250 ppm (0.013 percent to 0.025 percent) at 60°C (140°F). This saturation value is the maximum amount of water the oil will hold at a given temperature without separating or becoming cloudy. At lower temperatures, the oil will not hold as much water. Saturation values will vary, depending mostly upon the type of oil and temperature. For petroleum base oils, such as MIL-L-17331 and MIL-L-17672 fluids, a water content less than 100 ppm (0.01 percent) is desirable. The water content for these oils shall not exceed 500 ppm (0.05 percent) for any sample. For MIL-H-19457 fluids which are somewhat hygroscopic (meaning they absorb water), a maximum water content of 3,000 ppm (0.30 percent) is allowed. For water emulsifying petroleum base fluids which emulsify the water and actually try to surround and hold the water droplets, a maximum water content of 20,000 ppm (2.0 percent) is allowed. As delivered, this fluid may contain as much as 1,000 ppm (0.10 percent). At water concentrations above the specified levels, system and fluid degradation are accelerated. Detailed procedures for handling water-contaminated hydraulic systems are presented in paragraph 556-8.7.

556-8.4 FLUID SAMPLES

556-8.4.1 GENERAL. Correct sampling of hydraulic fluids is as important to quality surveillance as proper testing. Incorrectly drawn samples can cause laboratory results to be meaningless or, even worse, misleading.

Directions for sampling can not be made sufficiently explicit for all cases. Judgment, skill, and experience must supplement any instructions. For these reasons, the person assigned to take samples should be trained, experienced, competent, and conscientious. The responsibility for taking and preparing samples should not be lightly delegated. Samples should be as representative of the product being sampled as is possible. Sample containers should be meticulously clean. During sampling, nothing should be allowed to touch the fluid or the inside of the container. Samples should be capped promptly and handled expeditiously.

556-8.4.2 HYDRAULIC SYSTEM SAMPLING. Operating equipment should be sampled in accordance with instructions given in the operating and maintenance manual for the particular equipment, or as directed by the MRC’s.

a. All samples should be taken from circulating systems, or immediately upon shutdown, while the hydraulic fluid is within 5°C (9°F) of normal system operating temperature. Systems not up to temperature may provide non-representative samples of system dirt and water content, and such samples should be avoided or so indicated on the analysis report. The first oil coming from the sampling point should be discarded as it can be very dirty and does not represent the system. As a general rule, a volume of oil equivalent to one to two times the volume of oil contained in the sampling line and valve should be displaced before taking the sample.

b. Ideally the sample should be taken from a sampling valve (such as a sampling valve per MIL-V-81940) installed specifically for sampling. A MIL-V-24695 vent valve with hose assembly can also be used for sampling. A MIL-V-81940 sampling valve should be attached to the hose assembly prior to connecting the hose to the vent valve (see Figure 556-8-1). Some shipboard equipments are equipped with sampling connections in the circulating lines. Preferably, the connections should be installed in vertical pipe runs. If installed in horizontal runs, they should be placed in the side, half way between the top and bottom of the pipe. When sampling valves are not installed, the taking of samples from locations where sediment or water can collect, such as dead ends of piping, tank drains, and low points of large pipes and filter bowls, should be avoided if possible. If sampling from pipe drains, allow sufficient flow from the drain before taking the sample to ensure a sample representative of the system. The preferred sampling point, in the absence of sampling or vent valves, is the pump discharge gage line. Sufficient fluid, approximately one quart, should be drained from the gage line before the sample is taken. The drained fluid should not be returned to the system. Samples are not to be taken from the tops of reservoirs or other locations where the contamination levels are normally low.

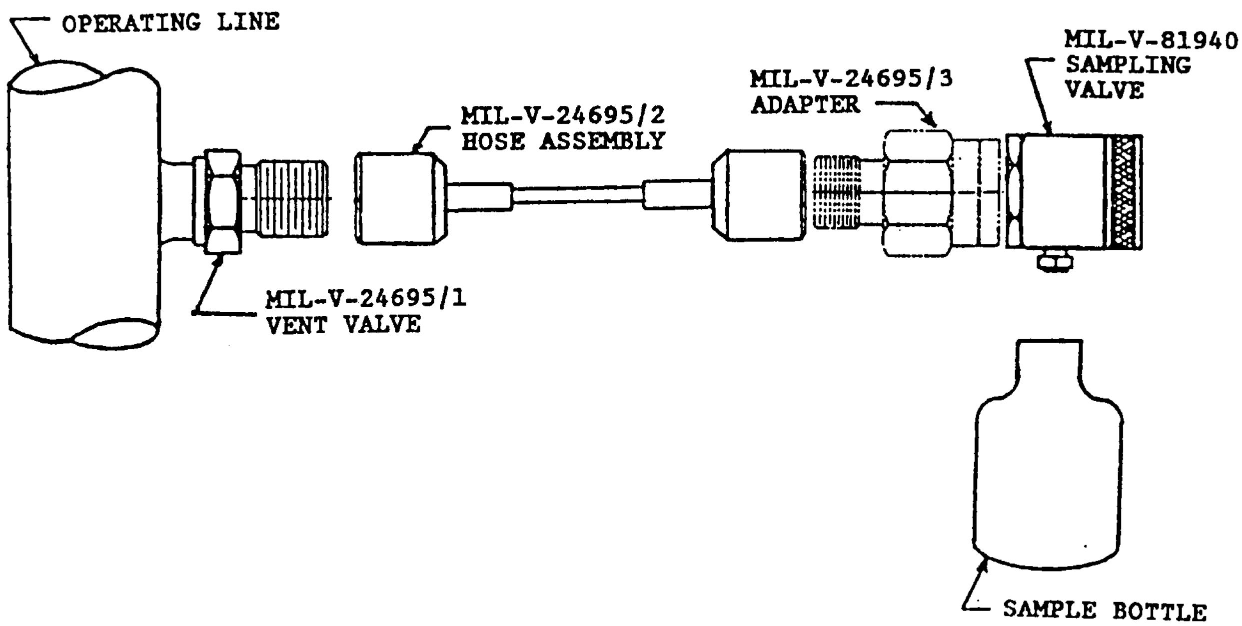


Figure 556-8-1 Connection of Sampling Valve to Vent Valve

c. Unless otherwise specified, sampling shall be in accordance with the following requirements:
   1 A minimum of one sample shall be taken for each system contained within a single compartment. For systems extending into two or more compartments, a second sample is required. (An exception to this criterion is submarine external hydraulic systems which require only one sample.)
   2 Original sample points should be labeled and the same sample points utilized each sampling period.
   3 For determining system cleanliness the following locations for sampling valves are recommended:
      (a) A return line location as close to the supply tank as possible but upstream of any return line filter.
      (b) For systems requiring a second sample, a location in either the supply or return line as far from the pump as practical.
   4 For determining performance of a specific filter, a sampling location immediately downstream of the filter is recommended.

556-8.4.2.1 Use of MIL-V-24695 Sampling Components. Figure 556-8-1 shows how a sample is taken using a MIL-V-24695/1 vent and test valve. The vent and test valve is installed into a hydraulic component port. This installation may be either permanent or temporary. The valve end which connects to the hose is equipped with a metric reverse buttress thread designed for easy attachment and removal by hand. The hose end fittings that mate with the valve are equipped with a probe that unseats a check valve in the vent and test valve. The special threads and the probe restrict unauthorized or unsafe system access. Connecting the discharge end of the hose to a valve or gage requires the use of a special adapter. The various configuration adapters are identified in MIL-V- 24695/3. The various adapters will permit connection to components with common size male threads of the UNF, metric and tapered pipe thread types. For sampling, a MIL-V-81940/4-1 valve should be connected to the hose using the appropriate adapter.

556-8.4.3 HYDRAULIC COMPONENT SAMPLING. All components should be verified to be clean before they are installed in a system. The most expedient way to obtain clean components is to invoke adequate cleanliness requirements at the time of procurement. New and repaired components which are known to be clean shall be kept sealed and wrapped until time for installation in a clean system. If the condition of a component is unknown, or if caps and plugs have been removed and the component internals have been exposed to possible contamination, sampling and testing to ensure adequate cleanliness should be accomplished prior to installation. Samples obtained from components should indicate at least the same degree of cleanliness that is required of the system. This action is important to prevent damage to the component when the system is put into operation. In addition, dirt which is allowed to remain in a component can be quite difficult to remove, and will contribute to such problems as reduced seal life, scored cylinder bodies, and plugged orifices. Because of the variety of hydraulic system components, specific guidance for sampling can not be provided. If the component contains fluid, samples may be obtained from vents or drains. Partial disassembly may be possible on some components to allow sampling of residual fluid from component internals. The important things to remember are that the sample must be representative of the component, and that the component must not be contaminated in the process of taking samples.

556-8.4.4 SAMPLE CONTAINERS. In general, any clean, reusable bottle is acceptable for collecting fluid. Frequently, medicinal-type bottles of 8-ounce or 16-ounce capacity are readily available and are of adequate size for most analysis requirements. When shipment of the samples is required, protective shipping containers with four one-quart bottles are available from the supply system. Replacement top and bottom cushioning (inner pack) with four replacement bottles are obtainable from supply as standard stock items. Samples shall be collected in bottles which have been cleaned in accordance with Federal Test Method Standard No. 791b, Method 3009.2 or SAE ARP 598. In lieu of using bottles, the hydraulic fluid can be filtered through a 0.8 micrometer filter mounted in a self-cleaning plug-in sampler which is connected directly to the system. When the plug-in sampler (one available source: Millipore Corp., Bedford, Mass., Kit P/N XX64-037-30) is connected to the system, pressure at the sampling port should not exceed 100lb/in^2 during the sampling cycle. On high pressure systems, appropriate pressure reducing equipment should be mounted upstream of the sampling port to ensure 100 lb/in^2 or less at the sampling port.

556-8.4.5 SAMPLE IDENTIFICATION. Proper identification and accurate records of samples are absolutely necessary so that the test result may be correlated with samples submitted. The following minimum information should accompany the samples forwarded to the laboratory for analysis:

a. Name of ship and system samples

b. Type of fluid (2190 TEP, 2110TH, MIL-H-19457)

c. Date sample taken

d. System status at time of sampling (overhaul, new construction, operational)

e. Location in the system from which sample was taken, identified by sketch or plan reference of first report

f. Tests required (unless use limit tests are specifically identified, analysis shall be limited to water content and particle count)

g. Remarks (as required).

556-8.4.6 SAMPLE ANALYSES AND REPORTING. Ships or activities without analysis capabilities, shall submit samples to nearest naval activity with facilities, in accordance with NAVCOMPT Manual Volume 8. The proper requisition form is DD 1149. Refer to **NSTM Chapter 262, Lubricating Oils, Greases, Specialty Lubricants and Lubricating Systems,** for testing laboratories.

a. Fluid Systems Contamination Sampling Report. The Format of Table 556-8-3 shall be used for recording the result of samples analyzed for particulate and water content. The feedback information shall include:

   1 Ship and System Identification

   2 Activity performing analysis

   3 Date sample was taken

   4 System status at time of sampling (overhaul, new construction, routine)

   5 Location in the system from which sample was taken identified by sketch or plan reference in first report

   6 Analytical methods used in determining water and particulate levels

   7 Water content and particle counts

   8 Allowable limits for applicable system

   9 The presence of unusual contaminants, such as metal chips, shavings, or brass particles, should be noted under remarks, with an explanation if known such as a pump failure. Similarly, the source of excessive water should be noted if known.

b. Where samples exceed the acceptable contamination limit, the system shall be cleaned accordingly. However, resampling to verify the analyses is recommended prior to cleaning.

Table 556-8-3 HYDRAULIC SYSTEM CONTAMINATION REPORT

FROM (ACTIVITY)	SHIP	DATE OF REPORT
TO	ACTIVITY PERFORMING ANALYSIS	SHIP STATUS (CHECK ONE) OPERATIONAL OVERHAUL OTHER__________

ITEM		SAMPLE (Number of Particles per Millilitre)						ALLOWABLE LIMITS (TO BE COMPLETED BY THE REPORTING ACTIVITY)	
		RUN NO:	1	2	3	4	5	OVERHAUL	OPERATIONAL
DATE SAMPLE TAKEN									
SYSTEM									
LOCATION									
PARTICLES SIZE (MICROMETRES)	≥5	1							
		2							
		3							
		AVERAGE							
	≥15	1							
		2							
		3							
		AVERAGE							
	≥25								
	≥50								
	≥100								
WATER CONTENT (PERCENT)									
GRAVIMETRIC ANALYSIS (MILLIGRAMS/100ML)									

COMMENTS (SATISFACTORY, UNSATISFACTORY), UNUSUAL FINDINGS, ETC

ANALYTICAL METHOD USED: FOR WATER (CHECK ONE)	MANUAL KARL FISCHER TITRATION (ASTM D1744) AUTOMATIC KARL FISCHER TRITRATION DISTILLATION (ASTM D–95)	FOR SOLIDS (CHECK)	GRAVIMETRIC (NFPA T2.9.14) AUTOMATIC PARTICLE COUNTER – (SPECIFY) MFR:________ MODEL:________ COUNTER CALIBRATION METHOD USED:________

DISTRIBUTION: (1) Applicable Ship (2) Applicable Squadron	SIGNATURE (Reporting Activity)

556-8.5 ANALYTICAL PROCEDURES

556-8.5.1 WATER CONTENT DETERMINATION. Water content for MIL-H-5606, MIL-H-6083, MIL-L-17331, and MIL-H-17672 fluids shall be determined by ASTM-D1744, **Water in Liquid Petroleum Products** by Karl Fischer Reagent, or with commercially available automatic water titrators. If the water content is in excess of 0.1 percent, determination can be made by the distillation procedure of ASTM-D95, **Water in Petroleum and Other Bituminous Materials** . For MIL-H-19457 and water emulsifying petroleum base fluids, only the distillation procedure of ASTM-D95 is recommended.

556-8.5.2 PARTICULATE COUNT DETERMINATION. Particulate counts shall be determined by automatic particle counters. When using automatic particle counters for count measurement, the manufacturer's instructions shall be rigidly followed. To establish the instrument's counting accuracy, the particle counter shall be calibrated per standard calibration procedure. Several methods of calibration for automatic particle counters (APC's) are in use; however, the calibration method used provides significantly different measurement of solid particles in the fluid sample. The calibration methods usually employ either Air Cleaner Fine Test Dust (ACFTD) or spherical latex spheres. The particle sizes obtained based on spherical calibration are smaller than those obtained when AC fine test dust is used for calibration. For particles greater than 5 mm the size obtained using a counter with spherical calibration will be smaller by a factor of 0.77. The effect on particle counts is even more significant. At 5 mm, the ratio of the count with spherical calibration will be only 0.65 of the count with ACFTD calibration. With larger sizes this difference becomes more pronounced. For example, at 20 mm, the ratio with spherical calibration will be only 0.46 of that with ACFTD calibration. Selection of APC calibration method is left to each Navy Oil Analysis laboratory; however the method of calibration used shall be identified on the hydraulic system contamination reports (see Table 556-8-4). The cleanliness requirements identified in Table 556-8-5 are based on APC counts obtained with AC Fine Test Dust Calibration. Calibration with fine test dust per the procedure in ISO 4402 is recommended. If the counts are obtained using spherical calibration, the counts must be corrected to correspond with AC Fine Test Dust Calibration. Guidance on the conversion should be obtained from APC manufacturer or American National Standard ANSI/(NFPA) T2.9.6 R1-1990 ″Hydraulic Fluid Power - Calibration method for liquid automatic particle counters using latex spheres″ (Available from National Fluid Power Association, 3333 N. Mayfair Rd., Milwaukee, WI 53222).

Table 556-8-4 ALLOWABLE PARTICULATE CONTAMINATION LIMITS

Ship/System	Overhaul Requirements	Operating Requirements
	Number of Particles per Millilitre	
	Over 15 mm	**Over 15 m**
AGSS 555	80	160
DSRV 1 and 2	80	320
Other Submarines (SS, SSN, SSBN, NR-1, NHTV) Internal (main, Vital, Ship Service, Independent Steering & Diving Missile Support) Systems External Systems	160 320	320 640

Table 556-8-5 ALLOWABLE WATER CONTAMINATION LIMITS

Ship	Single Sample (% Volume)*	Average (% Volume)*
DSRV 1 and 2	0.05	0.05
AGSS 555	0.05	0.05
Other Submarines		
Internal Systems	0.05	0.05
External Systems	0.10	0.05

*The water content for any single sample shall not exceed the single sample limit, and the average of samples for any system shall not exceed the average limit listed above.

556-8.5.3 GRAVIMETRIC DETERMINATION. Particulate weights shall be determined by the procedure of NFPA T2.9.14, ″Hydraulic Fluid Power - Fluid Contamination - Determination of solid contamination level by the gravimetric method.″

556-8.6 SUBMARINE HYDRAULIC POWER AND CONTROL SYSTEMS HYDRAULIC FLUID CLEANLINESS REQUIREMENTS

556-8.6.1 CONTAMINATION LIMITS. The allowable particulates and water contamination limits for specific submarine hydraulic systems are established in Table 556-8-4 and Table 556-8-5 respectively. All of the particulate contamination limits of Table 556-8-4 are selected from ISO 4406 (see Table 556-8-2). These limits are considered to be within the state of the art for initial cleanliness and the capability of the installed filtration devices to maintain for reasonable periods of time. Past experience indicates that at the particle size above 15 micrometre (mm), these systems are normally between ISO 4406 class 10 and 16 (see Table 556-8-2) with most systems having a particle count of class 14 or cleaner, and less than 6mg/100mL of contaminant when analyzed by a gravimetric method. The allowable water contents of Table 556-8-5 apply only to ship systems utilizing MIL-L-17331 (2190 TEP) and MIL-H-17672 (2075TH, 2110TH, 2135TH). When PR-1192 fluid is used, the allowed single sample water content is 2.0 percent maximum. The average water content of PR-1192 fluids shall not exceed 1.0 percent. Systems with 1.0 to 10 percent water are limited to 60 days of operation. Systems with above 10 percent water should be cleaned as soon as possible. Where samples exceed the recommended contamination limits, the system shall be cleaned as required to meet these limits. Prior to cleaning, resampling to verify the analysis is recommended.

556-8.6.2 SAMPLING. Samples shall be taken in accordance with the requirements of paragraph 556-8.4.

556-8.6.3 SAMPLING FREQUENCY. Representative samples for in-service submarines shall be taken in accordance with the requirements outlined in paragraphs 556-8.6.3.1 through 556-8.6.5.

556-8.6.3.1 Submarines In Overhaul. Samples should be obtained:

a. Upon arrival for overhaul.

b. Not more than 48 hours after first operation of system pump during system overhaul.

c. Periodically until completion of overhaul.

  1 At not more than 90 day intervals if previous system samples were within specified limits.

2 Within 10 days of last system sampling if any system sample was not within specified limits.

d. Within 3 weeks before each sea trial but after any breach of the system for welding, brazing, or repair of a major component (pump, accumulator, steering, or diving cylinder).

e. During each sea trial or within 12 hours of completion of a trial.

NOTE

One sampling may satisfy more than one of the foregoing requirements.

556-8.6.3.2 Additional Submarine Samples. When the system sampling and cleanliness requirements of this chapter are contractually invoked, every sample in the last set of samples before completion of overhaul shall meet the overhaul-particulate requirements of Table 556-8-4 and the water-contamination limits of Table 556-8-5. For sea trials at the end of overhaul periods, the operating requirements of Table 556-8-4 must be met. Other samples which are required during overhaul are primarily to monitor the progress in obtaining and maintaining system cleanliness. However, when these samples do not meet the operating requirements of Table 556-8-4 or the water contamination limits of Table 556-8-5, corrective action shall be initiated to improve cleanliness to prevent excessive wear and damage to components by operation during the overhaul period. Compliance with system cleanliness requirements shall be based on specific sampling locations designated at the beginning of the overhaul. When a system sample fails to meet the specified overhaul particulate requirement of Table 556-8-4 or the water contamination levels of Table 556-8-5, a complete set of system samples must be taken within ten days. However, analysis will be required only for the type of contamination, water or particulate, for which the previous sampling did not meet the designated requirements. Samples from additional sampling points or at intervals other than those designated may be taken by the overhaul activity for their use in obtaining and maintaining system cleanliness but the analyses results need not be reported.

556-8.6.3.3 Operational Submarines. Samples are to be obtained:

a. At approximately 180 day intervals if last system sampling indicated system within limits.

b. At 30 day or more frequent intervals when last system sampling was not within limits.

556-8.6.4 ANALYTICAL PROCEDURES. Samples shall be analyzed for particulate counts and water content in accordance with the analytical procedures of paragraph 556-8.5. Filtering oil samples taken from new barrels and shipboard systems for particle weighing per NFPA T2.9.14 can be difficult, depending mainly upon the amount of contaminant in the sample and the viscosity of the oil. Generally, unused oils per MIL-L-17331 (MS2190TEP) properly diluted with solvent and using high vacuum (66cm mercury minimum) should pass through the filter in five to ten minutes. Used fluids are expected to contain more particulate matter, which may increase filtration times to approximately 30 minutes to one hour. Where the fluids are excessively contaminated or an unusual amount of very fine particles are present, filtration times have been known to exceed 24 hours. Furthermore, cold oil has a higher viscosity than warm oil, which will add to filtration times. Therefore, ensure that the oil samples are at least up to room temperature. Generally, the other hydraulic oils in use, such as those conforming to MIL-H-17672, are less viscous than MIL-L-17331 and should filter more easily.

556-8.6.5 REPORTING. The results of the analyses shall be reported in accordance with paragraph 556-8.4.6. Forwarding of analyses reports to NAVSEA is not required. The following distribution of analyses reports is required.

a. Ships in Overhaul. The overhaul activity shall maintain a copy of each sampling report required by paragraph 556-8.6.3.1 for a period of one year following completion of overhaul. In addition, one copy of each analysis report shall be forwarded to the ship and to the squadron to which the ship is assigned within ten days of sampling.

b. Operating Ships. The analyzing activity shall report the analysis results to the ship with a copy to the squadron to which the ship is assigned.

556-8.7 WATER CONTAMINATED HYDRAULIC SYSTEMS

556-8.7.1 HYDRAULIC FLUID. Hydraulic fluid should be kept as free of water as possible. When water contamination is encountered, the urgency and type of action required depends upon the amount of water, the type of hydraulic fluid, and the characteristics of the hydraulic system. The source of water contamination should be identified and eliminated to prevent recontamination.

556-8.7.1.1 Petroleum Base Fluids. For petroleum base fluids, including MIL-H-17672 (2075TH, 2110TH, 2135TH) and MIL-L-17331 (2190TEP), an average in-service water content of less than 0.05 percent by volume should be maintained. The presence of water will generally cause these fluids to become cloudy at concentrations above 0.05 percent. Fluid samples should be inspected for evidence of water contamination in the following forms:

a. Emulsification: cloudy or milky appearance

b. Freewater: layer of water beneath the fluid

c. Water strings: milky-appearing strings in the fluid

d. Water Pockets: cloudy or milky spots within the fluid

Fluid samples that exhibit signs of freewater, water strings, or water pockets have already exceeded the saturation value of the fluid. Fluid samples that exhibit emulsification (cloudiness) at temperatures below the normal system operating temperature should be heated to 55°C ± 5°C (131°F ± 9°F). A bright sample at 60°C (140°F) or lower temperature indicates that the water concentration is below 0.05 percent. When excessive water, particularly sea water, is present in ship systems with petroleum base hydraulic fluids (except water emulsifying type), the actions discussed in paragraphs 556-8.7.2 and 556-8.7.2.1 should be used to reduce water content.

556-8.7.1.2 MIL-H-19457 Phosphate Ester Base Fluids. For fluids conforming to MIL-H-19457, an average in-service water content of less than 0.20 percent by volume should be maintained. Water concentrations greater than 0.20 percent will generally cause the fluid to appear cloudy with entrained water droplets. The presence of water in a cloudy sample can be verified using the ″crackle″ test. The test is performed by heating a small sample of fluid above 104°C (220°F). Any crackling, sputtering, or bubbling indicates a water content greater than 0.20 percent. When excessive water, particularly seawater, is present in ship systems using MIL-H-19457 fluid, action should be taken to reduce the water content following the guidance in paragraphs 556-8.7.2 and 556-8.7.2.1. Ensure that the purification unit's seals and filter media are compatible with MIL-H-19457 phosphate ester base fluid.

556-8.7.2 WATER REMOVAL EQUIPMENT AND PROCEDURES. The preferred maintenance action is to remove the water by processing the hydraulic fluid through water removal equipment. MIL-L-17331 and MIL-H-17672 fluids have been effectively dried with low temperature vacuum distillation, coalescer, paper filter, and centrifuge-type water-removal equipment. However, laboratory reports indicate that some water removal equipments may remove some fluid additives, or otherwise adversely affect the total additive package. As a result of limited test data, equipments which are described as coalescer units or equipments which utilize coalescers in a phase of the purification, are not recommended for use.

a. Fleet experience with the other types of water removal units mentioned above have been quite satisfactory. However, if the processed hydraulic fluid is not clear and bright upon completion of water removal, the fluid should be drained, and a fresh charge of the same type fluid added. During fluid processing, continued operation and cycling of hydraulic system components is required to provide the circulation necessary to pick up water from deadened and low flow areas. To facilitate cleanup, all accessible low points should be frequently drained of accumulated water. Adequate particulate filtration, generally by five micrometer absolute or finer filters, is required to remove accumulated sea salts. However, laboratory tests have shown that the AN 6236 size filters of MIL-F-5504, which are rated approximately ten micrometer nominal, will also remove sea salts, probably because of the high efficiency (98 percent) of the filtration media.

b. When excessive contamination is encountered in submarine hydraulic systems, and access to submarine tender or shore water removal facilities is not possible within five days, the lubrication system oil purifier can be connected into the hydraulic system. At the first opportunity, the hydraulic fluid should be analyzed for dirt and water content, aluminum components inspected in accordance with paragraph 556-9.1, and the hydraulic system cleaned and restored as required.

556-8.7.2.1 Drain and Fill. If water removal equipment cannot be utilized, the hydraulic system should be completely drained of all contaminated fluid immediately after operation (while the fluid is still warm, and maximum dirt and water are in suspension). Wipe or otherwise hand clean all accessible areas, such as fluid tanks and reservoirs. Refill with clean water-free fluid of the same type and circulate the system well. If tests on representative samples of the new fluid still indicate excessive water, circulate the system well, drain completely, and refill again. Repeat the circulate, drain, and refill procedure until the water levels are below 0.03 percent. Filters (25 micron absolute or finer are recommended) must be installed, and maintained during circulation to protect system components as well as to clean the system and fluid.

556-8.7.3 WATER EMULSIFYING FLUIDS. For E.F. Houghton PR-1192 water emulsifying fluids, an average in-service water content of less than 1.0 percent by volume is recommended, although some corrosion protection is provided by the fluid at higher water concentrations. Systems with one to ten percent water content shall be limited to sixty days operation. Water in excess of ten percent should be removed as soon as possible. In addition to accelerated corrosion, water in excess of ten percent may result in fluid viscosity increases that adversely affect system component operation. The presence of water will usually cause these fluids to become cloudy at concentrations above 1.0 percent.

a. When excessive water is encountered in water emulsifying fluids, the recommended corrective action to restore the hydraulic system is a series of drain and fill operations (see paragraph 556-8.7.2.1). Because water emulsifying fluids form water-in-oil emulsions, the operation of system components prior to draining will result in large amounts of water and dirt being held by the oil and subsequently removed with the fluid. Repeat the circulation, draining, and refilling sequence until the water levels are reduced to between 0.010 percent and 0.30 percent.

b. Water can also be removed from water emulsifying fluids by low-temperature vacuum distillation and centrifugal-type equipments. However, when this approach is used, the reclaimed fluid shall be subjected to those qualification tests of water emulsifying fluids necessary to ensure that the fluid characteristics have not been altered by the purification process. Additional guidance on performance testing of reclaimed water emulsifying fluids can be obtained from NAVSEA, if required. Water removal equipment that has been used to process water emulsifying fluids shall not be used to process other fluids until residual water emulsifying fluids have been removed. Relatively small quantities of water emulsifying fluids remaining in the equipment may adversely affect the performance of the next fluid to be processed.

556-8.7.4 INSPECTION. The fact that fluid samples indicate that water concentration is within recommended levels after corrective action has been taken does not preclude the possibility that free water droplets may remain in the system. Depending upon the extent and duration of the contamination, significant amounts of corrosion-and-wear debris, as well as water, may remain in valves, low spots, and areas of low-velocity flow. Critical components, such as pumps and control valves, should be checked for contaminants, corrosion, residual water, and cleaned or replaced as necessary.

556-8.8 PRESERVATION

556-8.8.1 SYSTEMS. Hydraulic systems that are to be left inactive for an extended period (six months or more) must be filled with a suitable preservative fluid to minimize rusting and corrosion. Unless fluid reservoirs are constructed of corrosion-resistant materials, separate expansion tanks should be installed above them so that the reservoirs may be completely filled. The elevated expansion tanks will also provide the space necessary for fluid expansion and will compensate for minor system leaks. The preservative to be used shall be system fluid. For systems using a petroleum base fluid. MIL-H-6083 shall be used as the preservative fluid when maximum corrosion protection is required.

556-8.8.2 COMPONENTS. Components which are disassembled and are to remain disassembled shall be cleaned, dried, and preserved in accordance with processes that will not harm the component and will provide protection against corrosion. See MIL-P-116 for guidance. Assembled components which are not immediately installed in the system also require preservation in accordance with the guidance in paragraphs 556-8.8.2.1 and 556-8.8.2.2. Components which are preserved shall be tagged to indicate the date of preservation, the type of preservative used, and any pertinent instructions as to preservative removal.

556-8.8.2.1 Component Internal Surfaces. The most commonly used preservative for hydraulic components is MIL-H-6083. The component shall be flushed or slushed with this fluid and then drained and capped. Slushing is accomplished by pouring the preservative into the component to be preserved and rotating, agitating, or positioning to ensure complete coverage of all internal surfaces. If the component is to be used in a system with petroleum base fluid, only draining (not flushing) is required before installation. If the component is to be used in a system with non-petroleum base fluid, the component must be flushed prior to installation. For systems using MIL-H-19457 phosphate ester base fluid, the component may be preserved by completely filling with the MIL-H-19457 fluid and tightly capping all ports to prevent leakage. Components preserved in this manner do not require flushing before installation in MIL-H-19457 systems. For systems using MIL-H-22072 water-glycol fluids, components may be preserved with a solution consisting of 10 percent E. F. Houghton Rust Veto 4221 and 90 percent MIL-H-22072. Circulate and drain the solution from the component prior to storage. Prior to installation, flush the component with MIL-H-22072 fluid.

556-8.8.2.2 Internal Surfaces (Long Term Protection). For long term protection of internal surfaces corrosion preventative compound MIL-C-16173 Grade 2 can be used. Use is recommended only for simple components where removal can be easily accomplished. This compound must be removed from internal parts prior to installation. Under adverse conditions, this preservative may become increasingly difficult to remove. Therefore, the internal surfaces of pumps, servo valves, and components with clearances between moving parts, orifices, or screens should not be treated with this preservative but preserved in accordance with paragraph 556-8.8.2.1.

556-8.8.2.3 Component External Surfaces. External portions of components subject to corrosion can be protected by use of a corrosion preventative compound in accordance with MIL-C-16173 Grade 1, 2 or 4. The Grades 1 and 4 compounds are normally applied where the preservative need not be removed for system operation, or where preservative removal by scraping or solvent action will not damage the item. The compounds must be removed from moving external parts where the preservative could interfere with movement or the operation of seals. The Grade 1 compound provides the best outdoor protection.

556-8.8.2.4 Preservative Removal. The MIL-C- 16173 Grade 1 compound is difficult to remove and is generally not used where removal will be necessary. The MIL-C-16173 Grades 2 and 4 compounds can be removed by PF-Degreaser or Electron Dielectric solvent. (See paragraph 556-8.12 for information on cleaning solvents and precautions for their use.) Surfaces cleaned with solvents will be left unprotected, and after solvent removal, should be immediately wetted with the system fluid unless welding or brazing will be required to reassemble the system. For preserved components used in petroleum base systems where degreasing will not be required for installation, cleaning oil conforming to MIL-C-15348 can be used to remove MIL-C-16173 Grade 2 preservative compounds. Immediately after the use of MIL-C-15348 fluid, the component shall be wetted, and the system filled shortly thereafter, with the system operating fluid.

556-8.8.3 CAPPING AND SEALING OPEN ENDS. Open ends must be capped or sealed to preserve cleanliness of assemblies for stowage, transit, or installation operations. All caps must have the same grade of cleanliness as the pipe or assembly to be sealed. Waterproof tape conforming to PPP-T-60D, electrical plastic tape, or other compatible tape may be used to hold caps in place. However, the use of any tape as a cap is prohibited. Caps are made in general accordance with MIL-C-5501.

a. In systems using petroleum-based hydraulic fluid, plastic or rubber material (with the exception of butyl rubber) may be used for caps. The pipe end shall be completely covered with sheet plastic or rubber (except butyl) and secured to the pipe outer wall with electrical plastic tape or other compatible tape. These materials may be used for threaded and unthreaded closures.

b. In systems using phosphate ester type, fire-resistant hydraulic fluid, butyl rubber and compatible plastics may be used for caps. The pipe end shall be completely covered with compatible sheet plastic butyl rubber, and secured to the pipe outer wall with a compatible tape.

556-8.8.4 SYSTEM RESTORATION. Systems that were preserved intact by filling with preservative oils conforming to MIL-H-6083, MIL-H-19457 or MIL-H-19457 (inhibited) do not generally require extensive flushing before becoming operational.

1. The following restoration sequence should be adequate:
   - a Drain or blow out as much preservative fluid as possible.
   - b Install new or cleaned system filter elements. Change elements as necessary during flushing operations c through h.
   - c Fill with new, clean system operating fluid.
   - d Circulate well through all piping and components.
   - e When well circulated and at or near normal operating temperature, drain or blow out as much fluid as possible.
   - f Refill with system fluid; circulate, and sample.
   - g Analyze samples to determine fluid viscosity and minimum flashpoint. Compare these values with the military specification requirements for the system fluid.

h If the flashpoint is more than 5°C (9°F) below specification requirements, or the viscosity varies more than 5 percent from that specified, repeat steps d through h before taking action to replace the fluid.

2. Systems returned to operation after having been disassembled should be flushed as necessary in general accordance with MIL-STD-419 to restore system cleanliness, and should then be sampled in accordance with paragraph 556-8.4. Unless otherwise specified, fluid contamination upon completion of flushing should not generally exceed the requirements of NAS 1638, class 10 (ISO 16).

556-8.9 SYSTEM REPAIR, TEST, AND INSPECTION

556-8.9.1 SAFETY PRECAUTIONS. When maintenance is performed on hydraulic piping systems, the safety precautions in Section 1 shall be followed.

556-8.9.2 SURFACE INSPECTION. Early detection and correction of hydraulic piping system defects are of utmost importance in ensuring operational reliability. Hydraulic piping systems should be surface inspected at least every 3 months to detect and eliminate leaks and to ensure satisfactory protection from external corrosion. Particular attention should be given to the undersides of piping, and piping in isolated areas, because these locations are most susceptible to corrosion.

556-8.9.3 HYDROSTATIC TESTS. Components that are completely disassembled, or any components, piping, or tanks that have been subject to repairs affecting structural integrity (such as welding, brazing, or reboring) shall be subject to a hydrostatic test. The hydrostatic test pressure shall be that indicated on system diagrams and drawings. For piping system weld repairs or piping system welded joints added as part of a system modification, the **Weld Repairs and Welded Joints Option** in **NSTM Chapter 505, Piping Systems** , may be substituted for the hydrostatic test specified above; however, this nondestructive test option does not apply where a hydrostatic test above normal system operating pressure is required in the **Submarine Safety Requirements Manual** (NAVSEA 0924-062-0010). Hydrostatic test pressure shall be that indicated on system diagrams and drawings. Hydrostatic test procedures and safety precautions shall be in accordance with **NSTM Chapter 505, Piping Systems,** except that hydrostatic tests of installed systems shall be conducted with system fluid in lieu of fresh water. Hydrostatic testing of system piping with water and other flushing fluids is permissible when accomplished in accordance with the requirements of MIL-STD-419, **Cleaning and Protecting Piping for Hydraulic Power Transmission Equipment.**

556-8.9.4 TECHNICAL REPAIR STANDARDS. Equipment and components shall be inspected and overhauled in accordance with Technical Repair Standards (TRS), Intermediate/Depot Level Maintenance Requirements Procedures (MRP's), or technical manual requirements. For equipment without formal repair procedures, the general guidance of this and other appropriate chapters shall be used.

556-8.9.5 CLEANING AND PRESERVATION. Cleaning including silver brazed flux removal, flushing, and preservation of hydraulic system piping and components shall be in accordance with MIL-STD-419, unless otherwise specified (See paragraphs 556-8.8 and 556-8.10). Grease, oil, and dirt may be removed from components and nearby surfaces using a solution consisting of MIL-D-16791 type 1 water-soluble detergent and water. For most cleaning operations, 1/4- to 1/2-ounce of detergent per gallon of water, preferably hot and fresh, is sufficient. Very heavy soils may require as much as one ounce of detergent for each gallon of water. Cold-water rinsing of cleaning areas is satisfactory, but hot water may be used when it is desirable that steel surfaces dry rapidly. Components and small accessible areas may also be wiped dry in lieu of rinsing.

556-8.10 HYDRAULIC SYSTEM FLUSHING

556-8.10.1 GENERAL GUIDANCE. Water contamination in operating systems can generally be remedied satisfactorily by the water removal procedures of paragraph 556-8.7. Similarly, excessive particulate contaminates may be removed from operating systems by the proper installation and maintenance of installed system filtration as discussed in Section 7. By means of the foregoing measures and the use of the ship's hydraulic pumps to effect circulation, system cleanliness can be maintained or restored with a minimum of downtime and little expenditure of money. However, under conditions of extreme contamination, more exhaustive measures (for example, including a system flush) may be required to restore system cleanliness. For example, removal of brazing flux or other debris resulting from extensive fabrication or pipework on the system during overhaul or refit (availability) generally requires special flushing procedures and equipment. Component failure or unusual hydraulic fluid breakdown may also result in sufficient contamination to require the use of high velocity, turbulent flushes. In some instances, the complete system will require flushing with auxiliary equipment; at other times, when contaminants are isolated to specific parts of the system, a partial flush will be satisfactory. Generally corrective action that requires flushing with external equipment will have to be done at a shipyard. Procedures for use in cleaning and flushing assembled hydraulic systems are provided in MIL-STD-419.

556-8.10.2 PROHIBITED FLUSHING SOLUTIONS. In general, any cleaning or flushing solution which has not been specifically approved by NAVSEA directly or through applicable Navy documents is not allowed. Severe corrosion problems were encountered in two nuclear submarine hydraulic systems because an unapproved flushing fluid was used. The unapproved shipyard cleaning procedure required the use of a 15 to 40 percent concentration of Oakite 131 in water at temperatures between 16°C and 71°C (60°F and 160°F). This product is primarily an inhibited phosphoric acid, and a 1-hour exposure at 71°C (160°F) would corrode practically any metal. In this case, the unapproved flushing solution excessively corroded the hydraulic piping system and aluminum components, resulting in fluid contamination, leaking seals, and requiring replacement of aluminum components and additional difficult and time-consuming system cleaning. It is practically impossible to undo the effects of such a corrosive attack on system components and piping. Do not use OAKITE products to clean or flush hydraulic systems. Do not use any solvents or other flushing fluids to clean components or systems unless approved by NAVSEA.

556-8.11 WIPING MATERIALS

556-8.11.1 GENERAL. Wiping materials are commonly used during hydraulic system maintenance to wipe down or to dry exposed surfaces of hydraulic components and associated assemblies. Several different types of wiping materials with a wide variety of characteristics are presently in common use in the fleet. Improper use of wiping materials can constitute, and has proven to be a source of, hydraulic system contamination. It is important, therefore, that maintenance personnel be familiar with the available materials and their proper application.

556-8.11.2 WIPER SELECTION. Wiping materials suitable for use in hydraulic system maintenance include rags and towels made of natural or synthetic fiber. Some types are referred to as disposable wiping cloths and other types can be laundered and reused. The type of wiping cloth selected for a given application will be determined by a number of considerations that may include:

a. Substances being wiped or absorbed

b. The amount of absorbency required

c. The required degree of cleanliness.

For purposes of contamination control, it is convenient to categorize available wiping materials by the degree of lint or built-in debris that they may deposit during use. In critical cleaning applications, such as those encountered during hydraulic component internal repairs, this factor itself will often determine the choice of wiping cloth. For selection of commonly available wipers, refer to Table 556-8-6.

Table 556-8-6 RECOMMEND WIPING CLOTHS

Lint Rating	Description	Characteristics	Application	Stock Number
High Limit	Baled rags, consisting of misc. size washed linen scraps.	High lint and other debris. High strength and absorbency. Cleanable.	General wipe-down and drying in noncritical applications (not lubricating or hydraulic system internals).	7920-00-205-1711 (50 lbs) (Approx. $31)
Moderate Lint (Fibers)	Wiping cloths, cellulose fibers. Fed. Spec. UU-T-595 (for general service) UU-T-598 (for delicate service and wiping transparent plastic.)	Moderate Line (fibers). Low wet strength.	Wipe-down and drying of all surfaces except those with critical cleanliness requirements. Can be used in critical applications if followed by solvent flush and air drying.	UU-T-595 1000 Sheets 7920-00-823-9772 (235 in^2) 7920-00-823-9773 (205 in^2) Approx. Cost $41, $35 UU-T-598 1350 Sheets 7920-00-965-1709 (264 in^2) Approx. Cost $25
Low Lint	Boxed wiping cloths, synthetic fiber, clean (not certified) MIL-C-85043 (Type II). See CAUTION	Low lint and particulates. Poor water absorbency. Cleanable. Good wet strength.	Wipe-down and drying of critical surfaces having cleanliness requirements. Recommended for shipboard or shop use on lubricating and hydraulic oil system internals.	7920-00-044-9281 10 lb. box. Approx. $30/box
Low Lint	Bagged wiping cloths, synthetic fiber, certified clean. MIL-C-85043 (Type I). See CAUTION	Very low lint and particulates. Poor water absorbency. Cleanable. Good wet strength. Expensive.	Wipe-down and drying of critical surfaces having ultrahigh cleanliness requirements. Primarily for clean room work.	7920-00-165-7195 10 lb. box. Approx. $44/box

556-8.11.3 LOW-LINT WIPERS. Two types of low-linting synthetic wiping cloths are specified for use in hydraulic maintenance and are available in Navy supply. MIL-C-85043 describes these materials and designates them as type I or type II wiping cloths.

CAUTION

Do not use low-lint synthetic wiping materials for wiping down large plastic areas or with volatile solvents having flashpoints less than 38°C (100°F). Use of low-lint synthetic material for these applications may result in the development of dangerous static charges. Use cotton flannel or cheesecloth instead.

a. Type I wiping cloths are nonlinting and are precleaned to a very low particulate level and supplied in sealed 10-pound bags. Type I wiping cloths are certified ultraclean and are to be used exclusively in clean rooms and controlled work areas during component rework, repair, and test.

b. Type II wiping cloths have the same nonlinting features as type I; however, they are not precleaned to as high a cleanliness standard. This material is to be used for general wipedown of hydraulic components, such as actuators, in place of conventional baled rags. Type II wiping cloths are also supplied in 10-pound bags.

556-8.12 CLEANING SOLVENTS

556-8.12.1 INTRODUCTION. The following paragraphs provide guidance regarding the selection and use of cleaning solvents as well as flushing and cleaning fluids that are not true solvents but do provide a degree of solvency in cleaning operations.

556-8.12.2 GENERAL. Since cleaning agents (solvents and solvent-like fluids) are frequently used in performing hydraulic system maintenance, the selection of an appropriate agent is an important consideration. The cleaning agent selected must be compatible with the cleaning method used and with the materials out of which the system is constructed. In addition, the agent must be capable of removing unwanted substances to the desired degree. Another important concern is the safety hazard that the agent may present. It is of the utmost importance that the user be aware of the hazards characteristic of each type of cleaning agent and exercise the required safety precautions. Disregard for any of these factors can result in injury to personnel, damage to equipment, or incomplete cleaning. Numerous solvents suitable for use as cleaning agents are available in the Navy supply system. To determine which solvent is best suited for a particular task, it is necessary to compare characteristics of each solvent with the detailed requirements of the specific cleaning operation. Important factors to be considered include materials to be cleaned, nature of substances to be removed, cleaning methods to be used, work environment, and personnel safety requirements. For general information on solvents used in hydraulic system maintenance see Table 556-8-7. In recent years, Methychloroform, Carbon Tetrachloride, and Chlorofluorocarbon (CFC) solvents have been identified as Ozone Depleting Substances (ODS). Global concern about the depletion of the earth's protective ozone layer, caused in part by the atmospheric release of ODS's, have prompted an International Agreement, signed in 1987, to call for a ban on the production of this class of compounds. In 1990 amendments to the U.S. Clean Air Act, Congress required a ban on ODS production by the year 2000, which has now been accelerated to December 1995. Accordingly, these solvents are not included in Table 556-8-7 and are no longer to be used. The hydraulic fluids identified in Table 556-8-7 are primarily suitable for flushing of hydraulic systems and components. All the hydraulic fluids listed in Table 556-8-7 are petroleum base and should not be used on systems and components with non-petroleum base fluids.

CAUTION

Do not use to wipe plastic areas or use P-D-680 or other volatile solvents having flashpoints less than 60°C (140°F).

Table 556-8-7 SOLVENTS FOR HYDRAULIC SYSTEM MAINTENANCE

Cleaning Fluid/Solvent	Effective in Removing	Cleaning Methods	Advantages	Safety Precautions/Disadvantages	Recommended Applications
* PF-Degreaser 7930-01-328-5959 PINT 7930-01-330-0187 QT 7930-01-328-5960 GAL 7930-01-328-2030 5 GAL 7930-01-328-4058 55 GAL	Oils, greases, waxes, dirt, dust, organic matters, carbon deposits.	Dip, slosh, spray, brush, wipe and ultrasonic cleaning.	Economical; Chemically stable; Non-chlorinated; Compatible with materials used in hydraulic components; Nontoxic; Non-narcotic; Exceptional Dielectric qualities.	Flammable, flash point 62.2°C (144°F). Note Keep away from open flames and ignition sources. Avoid prolonged skin contact. Wear rubber gloves and eye protection. Normal ventilation required.	Generally ideal for most shop and shipboard needs; General cleaning of all hydraulic components including surfaces coming in contact with system fluids.
* Electron Dielectric solvent 6850-01-371-8049 22 OZ spray bottle	Oils, greases, waxes, dirt, dust, organic matters, carbon deposits.	Dip, slosh, spray, brush, wipe and ultrasonic cleaning.	Economical; Chemically stable; Non-chlorinated; Compatible with materials used in hydraulic components; Nontoxic; Non-narcotic; Exceptional Dielectric qualities.	Flammable, flash point 63.9°C (147°F). Note Keep away from open flames and ignition sources; Avoid prolonged skin contact; Wear rubber gloves and eye protection; Normal ventilation required.	Generally ideal for most shop and shipboard needs; General cleaning of all hydraulic components including surfaces coming in contact with system fluids.
Water soluble detergent MIL-D-16791 Type 1 (1/4 to 1/2 ounce detergent per gallon of water, preferably hot).	Grease, oil, dirt.	Dip, slosh, spray, brush, flush or wipe and ultrasonic cleaning.	Good solvent power; Low flammability, flash point 177°C (350°F), but lower when mixed with water; Low toxicity; TLV unknown; very economical; Not chlorinated.	Must be removed with water. Residual water must be removed. Not suitable for most hydraulic system flush.	External to assembled components and piping where complete water rinse of solvent and removal of water is possible. Small-parts cleaning internally in ultrasonic tanks followed by thorough water rinse and drying.

Table 556-8-7 SOLVENTS FOR HYDRAULIC SYSTEM MAINTENANCE - Continued

Cleaning Fluid/Solvent	Effective in Removing	Cleaning Methods	Advantages	Safety Precautions/Disadvantages	Recommended Applications
Hydraulic Fluids: MIL-H-5606/83282 MIL-H-6083 MIL-H-17672 (MS 2075TH) (MS 2110TH (MS 2135TH) MIL-L-17331 MS 2190TEP) (Not true solvents but can be successfully employed as cleaning agents with proper equipment).	Oils; organic matter; light deposits of dust or dirt; Particulate contamination under high velocity flush.	Dip; slosh; spray; brush; flush; or wipe.	Readily available; Compatible with materials used in hydraulic components; Not chlorinated; Low toxicity; TLV unknown.	Do not use near hot surfaces or open flame; Oils perform better as solvent when heated to lower viscosity; Flammable; Not very effective as a solvent but will remove system dirt and water. Flashpoints: MIL-H-5606/6083 93°C(200°F) MIL-H-83282 204°C(400°F) MS 2075TH 157°C (315°F) MS 2110TH 163°C (325°F) MS 2135TH 171°C (340°F) MS 2190TEP 204°C (400°F)	Recommended for entire system flushes.

*CAUTION: Natural rubber products may swell if exposed for long periods of time
Drying may be accelerated by using warm air, filtered shop air or nitrogen - Fed Spec BB-N-41L

556-8.12.3 SOLVENT CLEANLINESS. Most cleaning compound specifications do not impose stringent requirements on the cleanliness of the fluid supplied. For clean room or critical cleaning applications, it is therefore required that the solvent be passed through a 3-micrometrer (absolute) filter prior to use. For system cleaning operations which may involve several hundred gallons of flushing oil or appropriate solvent, a quality filter of a least 15-micrometre absolute rating is usually considered sufficient.

556-8.12.4 SOLVENT TOXICITY. The Occupation Safety and Health Act (OSHA) sets Threshold Limit Value (TLV) recommendations that represent the established maximum solvent vapor concentrations (in air) to which personnel may be repeatedly exposed without possibly adverse affect. These limits are usually stated as parts of the solvent vapor per million parts of air compared on a volume basis. The highest recommended TLV for any solvent is 1,000 ppm, with some commonly used solvents having a TLV as low as 100 ppm. To ensure personnel safety, it is imperative that exposure to solvent vapors be limited to values less than the recommended TLV. Exposure to high temperature may dangerously increase the volatility of many solvents and must be avoided. In addition to producing high levels of solvent concentration, elevated temperatures may result in the formation of toxic or acidic fumes or of potentially explosive mixtures. Therefore, whenever solvents are in use, ensure adequate ventilation at all times and avoid solvent vapor contact with hot surfaces or open flame.

556-8.12.5 SOLVENT FLAMMABILITY. Flashpoint, fire point, and autoignition point are temperature values that describe the flammability of the solvent. The flashpoint occurs at the lowest value and should be seriously considered as the danger point at and above which fires may be easily started.

556-8.12.5.1 Flashpoint. The flashpoint is determined by raising the temperature until sufficient vapor is given off to produce momentary ignition when exposed to a flame under specific conditions.

556-8.12.5.2 Fire Point. The fire point is the lowest temperature at which a volatile combustible substance will burn continuously in air once its vapor has been ignited.

556-8.12.5.3 Autoignition Point. The autoignition point is the lowest temperature at which a combustible substance, when heated, will self-ignite in air and continue to burn.

556-8.12.5.4 Solvent Disposal. Used solvents are to be stored in cans or drums for shore disposal. See **NSTM Chapter 670, Stowage, Handling and Disposal of Hazardous General Use Consumables** and **NSTM Chapter 593, Pollution Control,** for additional guidance.

556-8.13 CLEANING METHODS.

a. Non-metallic parts such as O-rings:
   1 Clean with water and nonionic detergent per MIL-D-16791, type 1.
   2 Rinse with water and then with isopropyl alcohol per Fed Spec TT-I-735, Grade A.
   3 Dry using filtered shop air or nitrogen per Fed Spec BB-N-411, Class 1 Grade B.

b. Mechanical parts such as internal components and bodies:
   1 Clean exterior surfaces thoroughly with filtered Grade K-1 kerosene or nonionic detergent per MIL-D-16791, type 1.
   2 Disassemble and clean all parts with Grade K-1 kerosene until no grease or oil film is present.

NOTE

For some parts, this may require changing the kerosene at times to achieve the cleanliness level required.

3 Dry parts and reassemble.

NOTE

A slight kerosene film is not detrimental.

4 If further cleaning is required, use isopropyl alcohol per Fed Spec TT-I-735, Grade A and dry.

5 Clean parts that require further cleaning for processes such as dye penetrant (PT) inspection with approved non-chlorinated dye penetrant (PT) cleaner.

c. Filters:

1 Clean the filter per paragraph 556-7.8.

SECTION 9.

SUBMARINE HYDRAULIC SYSTEM ALUMINUM COMPONENTS

556-9.1 STRESS CORROSION CRACKING OF ALUMINUM ALLOYS

556-9.1.1 GENERAL. Stress corrosion cracking failures of wrought, high strength, aluminum alloy parts have been attributed to the following combination of factors:

a. Presence of a sustained surface tensile stress developed as a result of assembly stresses and residual stresses due to heat treatment or forming, acting in a direction perpendicular to the plane of predominant grain flow

b. Presence of a corrosive environment, which need not be severe (water in a hydraulic system is a prime corrosive environment)

c. Existence, in the product, of a metallurgical condition which makes the product susceptible to stress corrosion

556-9.1.2 ALUMINUM ALLOYS SUBJECT TO STRESS CORROSION CRACKING. Table 556-9-1 shows the alloys (bare or alclad) in the tempers listed, and in stress-relieved temper modifications thereof.

Table 556-9-1 ALUMINUM ALLOYS SUBJECT TO STRESS CORROSION CRACKING

2011-T3	2024-T42	7075-T6	2014-T6*
2011-T4	2219-T31	7079-T6	2017-T4*
2014-T3	2219-T37	7079-T611	2024-T3*
2018-T61	2618-T61	7178-T6	2024-T4*
2024-T36	7001-T6	2014-T4*	2-24-T6*

*Alloys Most Likely to be Found in Submarine Hydraulic Components

556-9.1.3 IDENTIFICATION OF SUBMARINE HYDRAULIC COMPONENTS SUBJECT TO STRESS CORROSION CRACKING. Prior to the SSN 688 Class, submarine hydraulic control valves, subplates, manifolds, and actuators were often manufactured of aluminum alloys which were often susceptible to stress corrosion cracking. While most of these components were originally made of aluminum alloys which are susceptible, cracking problems have been found only in components using alloy 2014-T6. The most serious problems have been found on SSBN 608, SSBN 616, and SSBN 640 Class submarines equipped with Vickers valves which used 2014-T6 alloy extensively. Other manufacturers of valves usually used one of the 2024 alloys in preference to 2014-T6 (except for large valves or manifolds which could not be made of 2024). There are several ways to identify valves which may be subject to stress corrosion cracking.

a. One method is by review of component drawings to see if susceptible alloys and tempers of aluminum are used. For many ships lists of components containing susceptible materials have been prepared by shipyards to support overhaul inspections. Lists of Level 1 components, in accordance with **Piping Systems Material Identification and Control** , NAVSEA 0948-LP-045-7010, have been developed by NAVSEA

b. Often a more difficult problem is to identify components which have replacement bodies of a material which is not susceptible to stress corrosion cracking. Replacement components are to be marked with the alloy and temper of the aluminum. In addition, Vickers has used a blue anodizing for aluminum components of 7075-T73 and 6061-T6. However, other vendors have not always marked components of non-susceptible alloys. Unless positive identification is possible, the components should be considered as being the more susceptible of the possible aluminum alloys.

556-9.2 INSPECTION REQUIREMENTS

NOTE

For each assembly being inspected, the inspection shall be performed on all pressure boundary parts fabricated of susceptible alloys. As an example, for a hydraulic control valve assembly, inspection will typically include not only the valve body and any associated porting plugs, but also the end caps and subplate assembly.

556-9.2.1 PRE-INSPECTION CLEANING. Prior to inspection, components must be disassembled and cleaned to remove sludge, oil film, and corrosion deposits. Trichlorotrifluorethane (a freon-type fluid) per MIL-C-81302 or hot vapor degrease with trichloroethylene solvent in accordance with MIL-T-81533, followed by ultrasonic cleaning in a water solution containing two to three oz/gal of nonionic detergent per MIL-D-16791 is one satisfactory method of cleaning. See **Contamination Control Technology,** MIL-HDBK-407, for additional in formation on cleaning methods and procedures.

556-9.2.2 VISUAL INSPECTION. A visual inspection shall a made of all components including those for which a dye penetrant or fluorescent inspection is required. If cracks or excessive pitting are identified by the usual inspection, the component may usually be rejected without performing the penetrant inspection unless a permanent inspection is needed to distinguish between a scratch and a crack. Visual inspections shall a conducted with the use of a high intensity light source (flashlight with concentrated beam) and a dental or inspection mirror. (Stress corrosion cracks will be internal to the component unless the crack has propagated completely through the component.)

556-9.2.3 DYE OR FLUORESCENT PENETRANT INSPECTION. The performing activity has the option of performing the inspection by utilizing either a dye penetrant (visible dye) or fluorescent penetrant type inspection to the procedures of MIL-STD-271. The penetrant materials shall be in accordance with MIL-I-25135 Group II (visible dye) or group IV (fluorescent) material procedures do not involve the use of volatile solvents and are considered readily adaptable to shipboard and intermediate maintenance activity use. However, any of the MIL-1-25135 material groups II through VI inclusive, listed in MIL-STD-271, are considered satisfactory, and may a used by activities where procedures for their use have been established to the requirement of MIL-STD-271. Penetrant inspection of only internal surfaces is required. An illuminated borescope may be used for inspection of internal surfaces or for in-place inspection of large manifolds.

556-9.2.4 EXTERIOR SURFACE CORROSION INSPECTION. When components are inspected internally for stress corrosion cracking or pitting corrosion a quick visual inspection should also be made of the external surfaces for pitting and corrosion. This inspection should be concentrated on external surface area, near thin wall sections adjacent to internal pressurized passages. Where possible cracking is identified, a dye penetrant check shall be made.

556-9.2.5 INSPECTION PRIORITIES and ACCEPTANCE/REJECTION CRITERIA. Table 556-9-2 lists rejection criteria for aluminum component inspections based on the application criticality level. The application criticality level is based primarily on the criticality of the component to the safety and mission of the ship. Acceptance/rejection criteria shall be as indicated in Table 556-9-2 and as defined in paragraphs 556-9.2.5.1 through 556-9.2.5.3.

Table 556-9-2 INSPECTION PRIORITIES AND ACCEPTANCE/ REJECTION CRITERIA

Application Criticality Level	**Service**	**Internal Corrosion Allowable Pitting**		**External Corrosion Maximum Depth of Pitting as % of Wall Thickness**
		Maximum Depth (in)	**Maximum Diameter (in)**	
I	Level I in accordance with NAVSEA 0948-LP-045-7010 (Power transfer valves to steering and diving rams)	1/32	3/16	10
II	Sargent Actuators 1469A, 1489RA, 1489RA-1 for MSW Backup Valves on SSBN 608, SSBN 640 and SSN 637 Classes (Bodies and end caps)*	CANCELLED - SHIPALT's SSN 1047, SSN 1367, and SSBN 1291 are reported complete.		
IIIA	Normal and Emergency Steering and Diving Systems, Ship Service (Main and Vital) Hydraulic Power Plant	1/10	1/4	15
IIIB	Emergency Remote Closure Hydraulic System for Flooding Control	1/10	1/4	15
IIIC	Missile Tube Hydraulic System	1/10	1/4	15
IV	All other services	1/10	1/4	15

*These actuators when constructed of 2014T6 of 2014T6 or 2014T61 aluminum alloy have a history of stress corrosion cracking and are being replaced by ShipAlt action.

556-9.2.5.1 Cracking. Due to the possibility of total failure, any component showing signs of either internal or external cracking shall a replaced. If replacement bodies are not readily available, the cracked components should a isolated where feasible during periods of nonoperation to reduce the possibility of failure and minimize the results of any failure which might occur. In some cases, a cracked component can be interchanged with a similar component in a less critical application until a replacement is obtained.

556-9.2.5.2 Internal Pitting. Minor corrosion can often be removed with a fine emery cloth. Minor corrosion and pitting can be tolerated except for pitting on an O-ring sealing surface which could result in excessive leakage. Table 556-9-2 lists the maximum diameter and depth of pits which may be accepted based on the application criticality level.

556-9.2.5.3 External Pitting and Corrosion. External pitting and corrosion are generally not detrimental to component material integrity or operation. The most vulnerable areas are thin wall sections adjacent to internal pressurized passages. Disassembly of trim or removal of name plates for crack investigation is not required unless the exposed adjacent areas show evidence of excessive pitting. Replacement action should be initiated whenever the depth of external pitting exceeds the percentage of original wall thickness listed in Table 556-9-2 based on the application criticality level. Hydraulic actuators are often located in close proximity to bilge areas and are particularly vulnerable to pitting corrosion. After satisfactory inspection, actuators located in these areas should be coated externally using epoxypolyamide paint per MIL-P-24441/1 (formula 150) and MIL-P-24441/2 (formula 151). For guidance concerning application of this paint, see **NSTM Chapter 631, Preservation of Ships in Service.**

556-9.2.6 INSPECTION TYPE AND FREQUENCY. The type and frequency of inspection is based on the vulnerability of the material of the component to stress corrosion cracking and the application criticality level of the component. Table 556-9-3 indicates the type (visual or penetrant) inspection required and the frequency. Components of 6061-T6 aluminum or titanium 6A1-4V wrought alloy do not require special inspections. Table 556-9-2 also identifies the requirement for inspections during any component disassembly and requirements for special inspection of components in seawater contamination system.

Table 556-9-3 TYPE AND PERIODICITY OF INTERNAL INSPECTIONS BASED ON APPLICATION PRIORITY AND ALUMINUM ALLOY

Application Criticality Level	**Pitting and Stress Corrosion Inspection**		**Pitting Corrosion Inspection of Alloy 7075-T73**
	All Tempers of 2014 and 2017	**All Tempers of 2024 and Other Aluminum Alloys Subject to Stress Corrosion Cracking**	
I	Fluorescent or dye penetrant (12 to 18 Months)	Fluorescent or dye penetrant (each ship overhaul)	Visual (each ship overhaul)
II	Canceled - SHIPALTS SSN 1047, SSN 1367 and SSBN 1291 are reported complete.		
IIIA	Fluorescent or dye penetrant (each ship overhaul)	Visual (each ship overhaul)	Visual (each ship overhaul)
IIIB	Visual	Visual	Visual

Table 556-9-3 TYPE AND PERIODICITY OF INTERNAL INSPECTIONS

BASED ON APPLICATION PRIORITY AND ALUMINUM ALLOY -

Continued

Application Criticality Level	Pitting and Stress Corrosion Inspection		Pitting Corrosion Inspection of Alloy 7075-T73
	All Tempers of 2014 and 2017	All Tempers of 2024 and Other Aluminum Alloys Subject to Stress Corrosion Cracking	
IIIC and IV	Visual	Visual	Visual
Special Inspection. An inspection (visual or penetrant as identified above) shall be accomplished without appreciable delay whenever the hydraulic system in which the components are installed has been subject to an avrage water contamination level of 0.5 percent of higher. For systems using E.F. Houghton PR-1192 water emulsifying fluid a special inspection is not required unless the average water contant exceeds 2.0 percent. Component Maintenance Inspection. Components shall be inspected whenever disassembled for repair, overhaul, or seal replacement. Periodic Inspection. Components shall be inspected at the periodicity specified. A visual inspection may be substituted for a penetrant inspection if disassembly for repair or seal replacement occurs before the minimum time for periodic inspection.			

556-9.2.7 RECORD OF INSPECTED COMPONENTS. For all application criticality Level I components requiring inspection at periodic intervals a record of the inspection shall be made for retention by ship's force as an aid in scheduling subsequent inspections. The information in subparagraphs a. through h. should be listed on the inspection record:

a. Type of component (such as control valve, manifold, subplate, actuator)

b. System identification number (such as HMV-1120)

c. Manufacturer's name and part number (also serial number if available)

d. Aluminum alloy of the component

e. Application criticality level

f. Date of inspection

g. Summary of inspection finding (absence of defects, minor pitting, or an excessive number of small pits)

h. Statement as to whether evidence of water contamination was found during inspection.

556-9.2.8 REPORTING CRACKED COMPONENTS. To provide information regarding the extent of cracking, an inspection report shall be submitted to NAVSEA for each component rejected due to cracking. For component parts rejected because of cracking, the defective part (except for Vickers parts of alloy 2014T6) shall be held until NAVSEA has advised whether the defective piece is desired for analysis. The information to be included in the report shall be the same as identified above for inspection records. This inspection reporting requirement has been determined to be exempt from report control procedures.

556-9.3 COMPONENT BODIES REPLACEMENT REQUIREMENTS

556-9.3.1 MATERIAL REQUIREMENTS. For replacement components forming a pressure boundary (body, end caps, subplates, manifolds, plugs, and so forth) the material selected shall have properties which ensure adequate strength and resistance to corrosion and fatigue. For steering and diving power transfer valves and other Level I components, replacement component material shall be wrought titanium alloy (MIL-T-9047, composition 6A1-4V or 6A1-4V ELI, previously composition 6 or 7). The selection of other materials or new component designs for Level I applications, is subject of specific approval by NAVSEA. For other applications, the mechanically stress-relieved aluminum alloys 2024-T351, 2024-T851, 7075-T7351, or 7075-T7352 may be used for replacement components. The lower strength aluminum alloy 6061-T6 in a mechanically stress-relieved condition can also be used except where a design analysis indicates that the design will be marginal in strength or fatigue.

556-9.3.2 STRESS ANALYSIS REQUIREMENTS. When a replacement component is to be fabricated from 6061-T6 aluminum alloy and the original component was fabricated from a higher strength alloy such as 2014-T6, verification shall be made that the direct material substitution is acceptable from a strength standpoint. The verifying stress analysis need only be performed for replacement components that are subjected to essentially continuous cyclic type applications. Examples are steering and diving emergency control valves, servo valves, and power plant bypass and bypass pilot control valves. Additionally, rotary actuator designs shall be analyzed for material substitution including dynamic stress analysis, underwater explosion, and high shock as required by specific application. A number of components have been approved for fabrication from 6061-T6 alloy. The vendor normally has identified this on the component master drawing for replacement components used in cyclic applications, as defined above, for which alloy 6061-T6 is requested for fabrication. The procurement document also will note that a stress analysis shall be performed if previous approval for 6061-T6 alloy substitution can not be verified. Aluminum alloy 6061-T6 shall not be used when the calculated assembly fastener torque or calculated stress levels using applicable stress concentration factors exceeds the values in subparagraphs a and b:

a. Compressive or tensile stress in excess of 14,000 lb/in^2 for any pressure-containing part (body, end caps, subplate, and so forth) when pressurized to one and one-half times nominal operating pressure.

b. Torque values for assembly or foundation bolts higher than the maximum of Table 556-10-1 and Table 556-10-2 in Section 10 of this NSTM chapter.

556-9.3.3 FIRST ARTICLE ACCEPTANCE TESTING. First article acceptance tests are not required when 2024-T351, 7075-T7351, or 7075-T7352 aluminum alloys are substituted for 2,000 series alloy. First article tests for component bodies in which 6061-T6 is substituted for aluminum is required only if engineering analysis indicates that the replacement part may not be able to pass original acceptance (or qualification) tests due to the material replacement. In such cases utilization of 2024-T351, 7075-T7351, or 7075-T7352 materials in lieu of 6061-T6 is considered preferable.

556-9.4 REPLACEMENT COMPONENTS MATERIAL IDENTIFICATION REQUIREMENTS

556-9.4.1 GENERAL. Identification and marking of aluminum replacement components is required in order to avoid unnecessary future inspections of nonsusceptible alloys.

556-9.4.2 LEVEL I MARKING. All replacement components (valves, subplates, manifolds) between the steering and diving power transfer valves and their rams, inclusive, require Level I material identification and control in accordance with **Piping Systems Material Identification and Control,** NAVSEA 0978-LP- 045-7010.

556-9.4.3 ALLOY AND TEMPER MARKING. The alloy and temper of all new and replacement aluminum pressure containing parts for both Level I and non-Level I applications shall a permanently marked on the part by one of the permanent methods listed in MIL-STD-791. Permanent marking of alloy and temper is not required if the component manufacturer has implemented a material control system in which a change in material requires a change in part number. Aluminum quills or ferrules which are completely internal to the valve assembly specifically are exempt from this marking requirement.

SECTION 10.

HYDRAULIC COMPONENT FASTENERS

556-10.1 HYDRAULIC COMPONENT FASTENER ASSEMBLY TORQUE REQUIREMENTS

556-10.1.1 Failure of fasteners for hydraulic system component and flange assemblies is often due to improper tightening. When assembling components or attaching flanges to components the proper torque must be applied evenly to all fasteners to prevent overloading and resultant failure of one or more of the fasteners. During actual assembly, fasteners should be equally torqued in a cross pattern utilizing a calibrated torque wrench. See **NSTM Chapter 075, Threaded Fasteners,** for torquing procedures. The torque values used should be those indicated on component assembly drawings. When torques are not indicated on drawings, the required torque values may be calculated or the torque values of Table 556-10-1 used.

a. Selection of the proper torque is dependent upon a friction factor which can vary significantly. The friction factor is influenced by the materials comprising the fastener, the item being fastened, and the nut or manifold into which the fastener is screwed. This friction factor ranges from approximately 0.1 for well lubricated threads to 0.2 for unlubricated and clean threads.

b. In practice the determination of a friction factor is very difficult unless torque-tension equipment is used. Therefore, the normal practice is to select a torque which will be low enough to preclude breaking the bolt at a low friction factor yet high enough to provide the proper preload with a high friction factor.

Table 556-10-1 MAXIMUM RECOMMENDED TORQUE VALUES FOR CRES AND ALLOY STEEL FASTENERS OF VARIOUS TENSILE STRENGTHS

Bolts or Capscrew Nominal Diameter	**Thread Size**	**Maximum Recommended Seating Torque***				
		CRES	**Alloy Steel**			
			Minimum Tensile Strength (psi)**			
		70,000	**55,000**	**70,000**	**120,000**	**160,000**
0.190	24 UNC 32 UNF	13 in-lbs 15 in-lbs	16 in-lbs 19 in-lbs	21 in-lbs 24 in-lbs	36 in-lbs 40 in-lbs	48 in-lbs 55 in-lbs
1/4	20 UNC 28 UNF	32 in-lbs 37 in-lbs	40 in-lbs 45 in-lbs	50 in-lbs 55 in-lbs	85 in-lbs 100 in-lbs	115 in-lbs 130 in-lbs
5/16	18 UNC 24 UNF	65 in-lbs 70 in-lbs	80 in-lbs 90 in-lbs	100 in-lbs 115 in-lbs	175 in-lbs 195 in-lbs	235 in-lbs 260 in-lbs
3/8	16 UNC 24 UNF	10 ft-lbs 11 ft-lbs	12 ft-lbs 14 ft-lbs	15 ft-lbs 17 ft-lbs	26 ft-lbs 30 ft-lbs	35 ft-lbs 40 ft-lbs
7/16	14 UNC 20 UNF	16 ft-lbs 18 ft-lbs	19 ft-lbs 21 ft-lbs	23 ft-lbs 27 ft-lbs	42 ft-lbs 48 ft-lbs	56 ft-lbs 62 ft-lbs

Table 556-10-1 MAXIMUM RECOMMENDED TORQUE VALUES FOR CRES AND ALLOY STEEL FASTENERS OF VARIOUS TENSILE STRENGTHS - Continued

Bolts or Capscrew Nominal Diameter	**Thread Size**	**Maximum Recommended Seating Torque***				
		CRES	**Alloy Steel**			
			Minimum Tensile Strength (psi)**			
		70,000	**55,000**	**70,000**	**120,000**	**160,000**
1/2	13 UNC 20 UNF	24 ft-lbs 27 ft-lbs	29 ft-lbs 33 ft-lbs	37 ft-lbs 42 ft-lbs	65 ft-lbs 70 ft-lbs	85 ft-lbs 95 ft-lbs
9/16	12 UNC 18 UNF	35 ft-lbs 39 ft-lbs	42 ft-lbs 47 ft-lbs	55 ft-lbs 60 ft-lbs	90 ft-lbs 100 ft-lbs	125 ft-lbs 135 ft-lbs
5/8	11 UNC 18 UNF	48 ft-lbs 54 ft-lbs	55 ft-lbs 65 ft-lbs	75 ft-lbs 85 ft-lbs	125 ft-lbs 140 ft-lbs	170 ft-lbs 190 ft-lbs
3/4	10 UNC 16 UNF	85 ft-lbs 95 ft-lbs	100 ft-lbs 115 ft-lbs	130 ft-lbs 145 ft-lbs	225 ft-lbs 250 ft-lbs	300 ft-lbs 335 ft-lbs
7/8	9 UNC 14 UNF	135 ft-lbs 150 ft-lbs	165 ft-lbs 180 ft-lbs	210 ft-lbs 230 ft-lbs	360 ft-lbs 400 ft-lbs	485 ft-lbs 535 ft-lbs
1	8 UNC 12 UNF	205 ft-lbs 225 ft-lbs	250 ft-lbs 275 ft-lbs	320 ft-lbs 350 ft-lbs	550 ft-lbs 600 ft-lbs	725 ft-lbs 795 ft-lbs
Torque will develop approximately 90 percent of the yield load for a 30,000 psi minimum yield strength CRES fastener and approximately 60 percent of the breaking load for an alloy steel fastener assuming a coefficient of friction of 0.10 and a coefficient of torque of 0.15 which are typical for well lubricated installations. See Table 556-10-5and Table 556-10-6 for tensile strength of cap screws. For tensile strength and marking of various grade steel bolts see MIL-HDBK-131. See Table 556-10-2 on torque limitations for fasteners used in aluminum components.						

556-10.2 HYDRAULIC COMPONENT FASTENERS ALLOWABLE TORQUE VALUES

556-10.2.1 The maximum torque which should be applied to a fastener is dependent upon several factors. First, the maximum torque is limited by the fastener size and to a lesser degree by the thread series. However, the strength of a fastener is also dependent upon the tensile strength of the material from which it is made. Table 556-10-1 gives maximum recommended torque values for various tensile strength fasteners based on torquing to 60 percent of the minimum tensile breaking load of the fastener with a coefficient of friction of 0.15. Since the coefficient of friction may vary considerably, the listed torque may subject the fastener to more than 60 percent of its breaking load if the actual friction factor is less than 0.15. However, even with a very low friction factor of 0.1 the torque will generate only 90 percent of the minimum breaking load.

a. When lower strength materials such as aluminum are secured with high strength steel fasteners, the maximum torque which may be applied is often limited by the lower strength material rather than the fastener strength. Usually fastener inserts, either helical coil or locked-in solid wall types, are used with aluminum components to increase the strength of the connection and to prevent damage to the aluminum threads through occasional disassembly and assembly. Even when inserts are used in aluminum components, the torque must be limited to prevent pulling the fastener inserts out of the aluminum or developing excessive bearing stress under the fastener head. Longer inserts have greater holding power and allow the fastener to be torqued to a higher value

b. For fasteners in aluminum and other low shear strength materials, torque values should be based on the alloy steel column of Table 556-10-1 listed in Table 556-10-2 unless one of the following conditions apply:

Table 556-10-2 TORQUE LIMITS FOR FASTENERS SCREWED INTO LOW SHEAR STRENGTH MATERIAL

Shear Strength of Material (psi)	**Typical Material**	**Insert Length Nominal Diameters**	**Base Torque Value on the Alloy Steel Column in Table 556-10-1 Listed Below**
20,000	Cast Aluminum Alloys such as 356-T6	No Inserts* 1 1-1/2 2	** 55K 70K 120K
30,000	Aluminum 6061-T6	No Inserts* 1 1-1/2 2	55K** 70K 120K 120K
40,000	Aluminum 2014 (T4, T6) 2024 (T351, T4, T6)	No Inserts* 1 1-1/2 2	70K** 70K 120K 160K
Shipbuilding specifications usually require inserts in all aluminum alloys. torque value is limited by depth of thread engagement torque values listed are for an engagement equivalent to the insert length. When torque values are listed for fasteners without inserts it is for an engagement equivalent to at least one nominal diameter of the fastener.			

1 Component drawings require a higher torque value.

2 Engineering calculations indicate a higher torque is satisfactory.

c. Fasteners for hydraulic components should be torqued to one of the following requirements listed in order of priority:

1 Torque values specified on component drawings or component technical manual.

2 Torque values calculated using the procedure of paragraph 556-10.3 or an alternate valid method. These torque values shall not exceed those allowed by Table 556-10-1 and Table 556-10-2. Normally, if the calculated value falls below 25 percent of the value given in Table 556-10-1, use a torque value of 25 percent of the table value. See the following CAUTION.

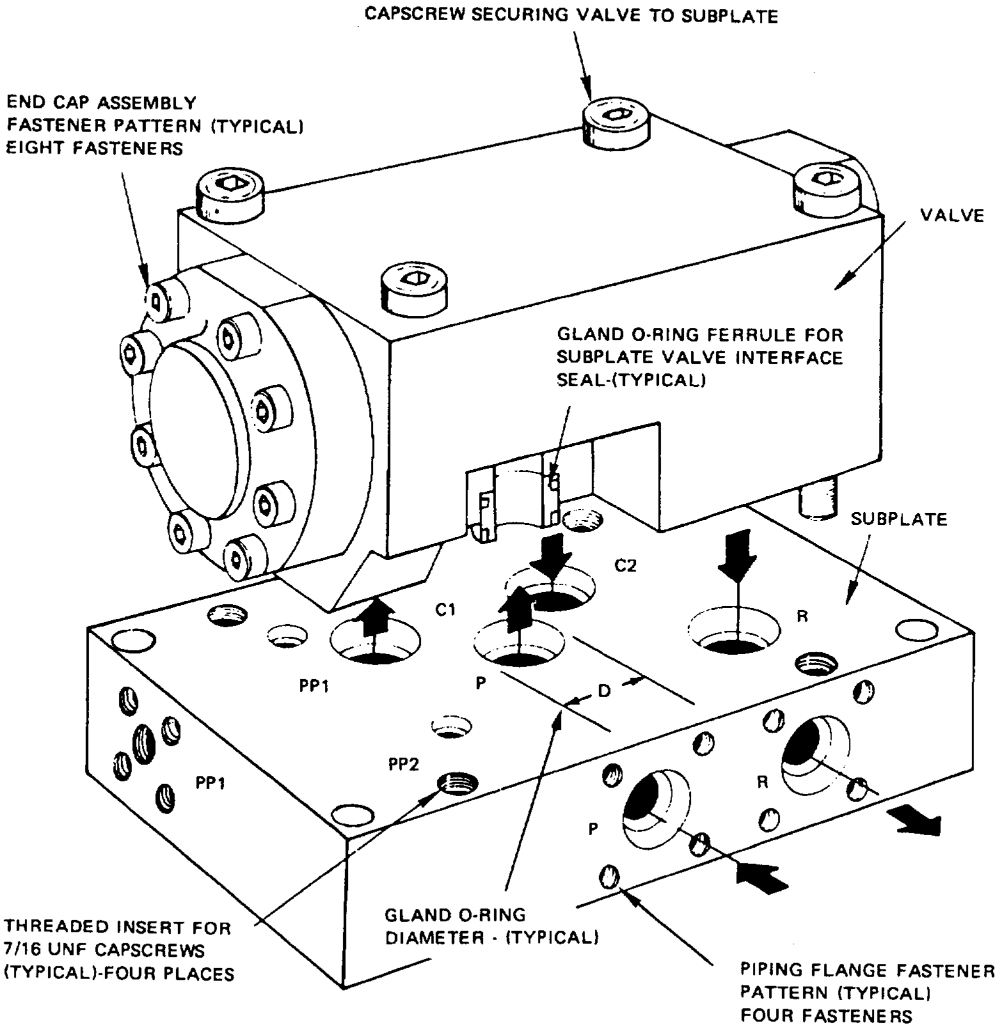
CAUTION

Care should be taken to avoid using torque values that result in damage or distortion of components.

3 Personnel unable to calculate torque values should use two-thirds of the maximum torque values given in Table 556-10-1. For aluminum and other low shear strength components, base torque values on two-thirds the maximum value obtained using Table 556-10-1 and Table 556-10-2 as prescribed in paragraph above. See the preceding CAUTION.

556-10.3 FASTENER ASSEMBLY TORQUE DETERMINATION

556-10.3.1 CALCULATION METHOD. The following procedure is used to determine assembly torque to be applied to hydraulic system component fasteners. Figure 556-10-1 shows a typical hydraulic control valve which will be used in illustrating the calculation method. For any particular component, the service loading force that the various bolting patterns must restrain is calculated.



PORT	GLAND O-RING DIAMETER (INCHES)
P	.993
C1	.993
C2	.993
R	.993
PP1	.361
PP2	.361

Figure 556-10-1 Typical Control Valve Assembly

1. First, determine the different bolting patterns involved. For example, with Figure 556-10-1 there are several bolting patterns involved.
   a Four bolt pattern - secures valve body to subplate.
   b Eight bolt pattern - secures end cap to valve body.
   c Four bolt pattern - secures pipe flange to subplate.
2. Once the various bolting patterns have been determined, calculate the force acting on each bolting pattern due to the system pressure loading. The force on a bolting pattern is calculated by multiplying the area subjected to pressure by the pressure which acts on the area. The force obtained is that which is tending to separate the assembly and which the bolting pattern must restrain. Normally, the maximum pressure to which the valve will be subjected is the hydrostatic test pressure. The hydrostatic test pressure for new components will normally be one and one-half or two times system operation pressure.
3. For all ports which can be subjected to supply pressure during normal operation, the hydrostatic test pressure based on supply pressure will be used for calculations. For ports subject only to return or tank pressure, calculations will be based on the return hydrostatic test pressure.

556-10.3.1.1 For example, for the valve body-subplate interface of Figure 556-10-1, the four capscrews holding the valve to the subplate are subjected to the forces created by pressure acting on the six ports between the valve and the subplate. The ports have a circular cross section and the area of each port can be calculated as:

$A = \pi D^2 /4 = 0.785\ D^2$ where D^2 is the seal diameter of the port in inches.

a. The method of determining the total force acting to separate the valve-subplate interface is shown in Table 556-10-3. The total force to which the bolts holding the valve to the subplate are subjected is the sum of the individual force developed by each valve port.

Table 556-10-3 DETERMINATION OF FASTENER LOADS FOR A VALVE-SUBPLATE INTERFACE

Port	Port Diameter (inches) D	D^2	Port Area (in^2) 0.785 D 2	Test Pressure (psi)	Force (lbs) Area x Pressure
P	0.993	0.986	0.775	4500	3,485
C1	0.993	0.986	0.775	4500	3,485
C2	0.993	0.986	0.775	4500	3,485
R	0.993	0.986	0.775	750	581
PP1	0.361	0.130	0.102	4500	459
PP2	0.361	0.130	0.102	4500	459
Total Load (Sum of Forces) 11,954					
Number of Fasteners (N) = Total Load = L_4 =					
N_4					
Load per Fastener = 2, 989					
Typical coefficients of torque are listed in Table 556-10-4. The selection of high coefficient of friction is a conservative approach as explained in paragraph 556-10.3.2.					

b. Once the load carried by each individual fastener or bolt has been calculated, the next step is to calculate the required assembly torque for each fastener. In calculating the load for a fastener, each fastener is assumed to carry an equal portion of the load. Actually, the loading may be uneven and therefore a safety factor (1.5) is used to allow for possible uneven loading.

c. The following formula is used to calculate the assembly torque for each fastener:

T = assembly torque (in-lbs) = L_F x D_F x C x SF

Where:

L_F = Load for each fastener (pounds)

D_F = Nominal fastener diameter (inches)

C = Coefficient of torque = 0.2*

SF = Safety factor = 1.5

Simplifying:

T = L_F X D_F X 0.2 X 1.5 in-lbs

T = 0.3 L_F X D_F in-lbs

NOTE

Typical coefficients of torque are listed in Table 556–10–4. The selection of high coefficient of friction is a conservative approach as explained in paragraph 556–10.3.2.

Table 556-10-4 APPROXIMATE COEFFICIENTS OF TORQUE

Thread and Bearing Area Condition	Coefficient of Friction	Coefficient of Torque
Well lubricated (Molybdenum disulfide	0.10	0.15
Dry (traces of cuttingfluid but no particles)	0.15	0.20

d. For the valve body-subplate interface of the example, the torque for each of the four 7/16-inch diameter fasteners would be:

T = 0.3 LF X DF = 0.3 X 2989 (lbs) X 7/16 (in)

T = 392 in-lbs

T = 392 in-lbs X (1 ft-lb/12 in-lbs) = 33 ft-lbs

556-10.3.2 ADEQUACY OF SAFETY FACTORS. A high friction factor is selected to ensure that a sufficient preload is obtained (see paragraph 556-10.1.1). The selection of a high friction factor plus a 1.5 safety factor for uneven loading represents a very conservative approach. If the calculated torque exceeds the recommended torque of Table 556-10-1 (based on fastener strength) by less than 50 percent, the fastener should be torqued to the value of Table 556-10-1. Where calculated torque exceeds the recommended torque of Table 556-10-1 by more than 50 percent, a higher strength fastener or a detailed engineering evaluation is required.

556-10.4 FASTENERS HARDWARE FOR HYDRAULIC COMPONENTS

556-10.4.1 IDENTIFICATION OF REPLACEMENT FASTENERS. Replacement fasteners should be readily identifiable from drawings, technical manuals and logistic support documentation such as Allowance Parts Lists

(APL's). However, this task is often considerably more difficult due to deficient component drawings and logistical support documentation. The following paragraphs provide guidance which may be used to assist in identifying the proper replacement fasteners.

556-10.4.1.1 Drawing Identification Requirements. Detailed component drawings should identify the fasteners by a military or industry part numbers. Unfortunately, many drawings for components do not comply with MIL-STD-100 drawing requirements. In many cases, fastener hardware is only identified by a Military Specification or by a proprietary manufacturer's part number without identifying the applicable Military or industry standard part identification number. If the fastener is identified by a military or industry part number, this number can be crossed directly to an NSN if the part is stocked in the system. If the part number is not identified on the component drawing, the Allowance Parts List should next be reviewed.

556-10.4.1.2 Identification of Fasteners on Allowance Parts Lists (APL's). In the past it was the general policy not to include fasteners on APL's unless the fasteners were carried as onboard spares. However, since the fasteners are often not properly identified on drawings, a policy is being implemented to identify replacement fastener hardware on new APL's even when no onboard spares are authorized by the APL. Some APL's have been revised; others will be revised only when being updated for other reasons or when revision is specifically requested. In identifying fasteners on APL's, cross references to component piece number and manufacturer's part number should be made for those applications in which the standard part identification number for the fastener is not identified on the component drawing. When fastener hardware is identified on APL's, the NSN will be identified in addition to the standard part identification number.

556-10.4.1.3 Identifying Replacement Fasteners When Support Documentation Is Lacking. When support documentation is inadequate to identify the standard part identification numbers for fastener hardware, the following approach is recommended:

1. Obtain the following information regarding the fastener from the component drawing or by inspection of the fastener.
   a Type fastener: Socket head cap screw, hex head cap screw, machine bolt, set screw, etc.
   b Fastener threads: Number per inch, other identification as to coarse or fine.
   c Dimensions: Diameter and length, threaded length.
   d Strength: (This information will usually not be available but in some cases drawings may identify tensile strength or an SAE grade).
2. Compare the fastener characteristics identified above with those fasteners identified in MIL-STD-1251 **Screws and Bolts, Preferred for Design, Listing of** . MIL-STD-1251 has a table of contents which identifies the screws and bolts by type. The listings in the document under type contain a figure showing the configuration of the bolt or screw to assist in identification.
   a First identify the type of fastener required.
   b Next, see if the desired material and protective finish (coating) and strength match those required.
   c Next see if the required diameter and thread size match.
   d Verify that the threaded length of the proposed replacement is adequate.
   e Finally, identify the dash number for the proper length. (Most screws and bolts are identified by the MS number and a dash number for length. In some cases, more than one dash number may be required to identify the fastener. In some cases it is necessary to refer to the applicable standard to identify the appropriate dash numbers.)

3. If a standard part number for the required fastener cannot be located in MIL-STD-1251 the next is to use the **Federal Supply Classification** to identify the fastener. The Federal Supply Classes for fasteners and related items are:

   5305 Screws 5310 Nuts and Washers

   5306 Bolts 5325 Fastening Devices

   5307 Studs 5340 Insert, Screw Thread There are two primary ways to access fasteners through the Federal Supply Classification. The first is through the use of the **Afloat Shopping Guide** and the second is the **Federal Supply Classification Listing of DoD Standardization Documents** which is a part of the Department of Defense Index of Specifications and Standards (DODISS). The use of these documents is described below.

   a **Afloat Shopping Guide (ASG).** The ASG lists by Class the most commonly used items. Less frequently used items may be stocked but not listed in the ASG. The description of items in the ASG is often incomplete and reference to the applicable standard may sometimes be necessary to determine suitability of the part. The applicable standard generally consists of a MS number and a dash number. If the applicable standard is not identified in the ASG, it is then necessary to access the technical characteristics for the NSN. NSN's are provided for all items in the ASG and therefore identification of the standard part number is not required to order the item.

   b **Federal Supply Classification Listing (DODISS).** This document is more comprehensive than the ASG but more difficult to use. Classes 5305 and 5306 alone list approximately 1000 standards for screws and bolts. Basically, the listing provides only the title of the standard and the preparing activity. Some standards list material and size in the title but for others it is often necessary to review the document to determine whether it is applicable. In every case it will be necessary to review the applicable document to determine if there is a standard part number which can be used to order the required part.

4. In some cases the Military or Federal Specification number can be used as a starting point to identify replacement fasteners.

   a Obtain the applicable specification and look in Section 2 under ″Applicable Documents″ to see if part standards are referenced. Also look in Section 6under ″Military Procurement.″ Section 6 usually requires that for military use the fasteners are to be limited to the variety shown on applicable Military or Industrial Standards and then identifies the standards.

   b Another alternative is to enter the Master Cross Reference List through the specification number. In fact, this may be the only way to identify many MIL-S-1222 fasteners which then requires viewing the technical requirements for up to 2000 NSN's in order to identify the applicable NSN. Fortunately, very few MIL-S-1222 fasteners are used for hydraulic system components.

556-10.5 CAP SCREWS AND INTERNAL WRENCHING BOLTS

556-10.5.1 SOCKET HEAD CAP SCREWS. These fasteners are often used in hydraulic systems such as submarines and advanced lightweight surface craft where the space and weight of the components is limited. The internal hex socket minimizes the size of components since no space is required outside the bolt head diameter for a wrench or socket. For socket head cap screws the head is cylindrical in shape, the sides of the heads are at right (90°) angles to surface into which the screw is threaded. (See paragraph 556-10.5.2.1 for a description of how cap screw heads differ from internal wrenching bolt heads.) Shipbuilding specifications have required that socket head cap screws be in accordance with FF-S-86. FF-S-86 itself requires that for military applications, the cap screws be to one of the dimensional standards listed in FF-S-86.

The following dimensional standards are listed in FF-S-86 and some are further identified in Table 556-10-5 and Table 556-10-6.

NAS 1351	NAS 1352	MS16995

MS16996	MS16997	MS16998
MS21262	MS21295	MS24667
MS24671	MS24673	MS24674
MS24678	MS35455	MS35456
MS35457	MS35458	MS35459
MS35460	MS35461	

Table 556-10-5 SOCKET-HEAD CAPSCREWS, SELF-LOCKING OR DRILLED FOR SAFETY WIRING

Procurement Specification	**Dimensional Specification**	**Thread Size**	**Length* Inches**	**Material**	**Tensile Strength**	**Marking Require-ments**
MIL-B-7838	MS 20004 thru MS 20024	1/4-28 UNJF-3A thru 1-1/2-12 UNJF-3A	0.75 to 6.500 3.375 to 8.000	Alloy Steel	160 KSI	MS number and manufacturer's identification on bolt head
NAS 159 (For new design use MIL-B-7838)	NAS 144 thru NAS 158 NAS 172 NAS 174 NAS 176	1/4-28 UNJF-3A thru 1-1/8-12 UNJF-3A 1-1/4-12 UNJF-3A 1-3/8-12 UNJF-3A 1-1/2-12 UNJF-3A	9/16 to 8 1-9/16 to 8 1-3/4 to 8 1-7/8 to 8 2 to 8	Alloy Steel	160-180 KSI	NAS part number (dash number for length optional) and manu<#0106> facturer's identifi-cation on bolt head
FF-S-86	NAS 1351 NAS 1352	No. 0-80 UNF-3A thru 1-12 UNF-3A No. 1-64 UNC-3A thru 1-1/2-6 UNC-2A	1/8 to 3/8 2-1/2 to 5 1/8 to 3/8 3-1/2 to 6	Alloy Steel CRES Heat resist-ing Steel	170-180 KSI (70-80 KSI) 160 KSI	Package to be marked with com-plete NAS Stan-dard Part Number Package to be marked with com-plete NAS Standard Part Number
FF-S-86 and MIL-F-18240	MS 21262#	No. 4-40 UNC-3A thru No. 8-32 UNC-3A No. 10-32 UNF-3A thru No. 5/8-18 UNF-3A	3/16 to 3/4 3/16 to 1-1/2 5/32 to 2 1 to 3	Alloy Steel	160 KSI	Circle of six raised or depressed dots on top of head
FF-S-86	MS 21295#	(Same as MS 21262)	(Same as MS 21262)	CRES	80 KSI	Circle of six raised or depressed dots on top of head

Table 556-10-5 SOCKET-HEAD CAPSCREWS, SELF-LOCKING OR DRILLED FOR SAFETY WIRING - Continued

Procurement Specification	Dimensional Specification	Thread Size	Length* Inches	Material	Tensile Strength	Marking Requirements
FF-S-86	MS 24677#	No. 4-40 UNC-3A thru 1-8 UNC-3A	1/4 to 3/4 2 to 6	Alloy Steel	170-180 KSI	Package only unless special marking is specified on procurement
FF-S-86	MS 24678##	No. 6-40 UNF-3A thru 5/8-18 UNF-3A	1/4 to 3/4 1 to 2-1/2	Alloy Steel	170-180 KSI	Package only unless special marking is specified on procurement
FF-S-86	MS 24673##	No. 10-32 UNF-3A thru 3/8-24 UNF-3A	3/8 to 1-1/2 3/4 to 1-1/2	CRES	70-80 KSI	Package only unless special marking is specified on procurement
FF-S-86	MS 24674#	No. 6-32 UNC-3A thru 5/8-11 UNC-3A	1/4 to 3/4 1 to 3	CRES	70-80 KSI	Package only unless special marking is specified on procurement
FF-S-86	As specified	As specified	As specified	Ni-Cu-Al QQ-N-286 Age Hardened	130 KSI	Marked •K• or $\frac{\text{Ni-Cu}}{\text{K}}$ with lot number identification per MS 18116 (Ships)
FF-S-86	MS16997#	No. 2-56 UNC-3A thru 1/8 UNC-3A	3/16 to 1/2 3-1/2 to 8	Alloy Steel	160 KSI	Package only unless special marking is specified on procurement
FF-S-86	MS 16998##	No. 0-80 UNF-3A thru 5/8-18 UNF-3A	1/8 to 1/2 1 to 3	Alloy Steel	160 KSI	Package only unless special marking is specified on procurement

Table 556-10-6 FF-S-85 HEXAGON-HEAD CAPSCREWS

Dimensional Standard	Thread Type	Thread diameter (in.)	Length* (in.)	Material	Tensile Strength (ksi)	Remarks
#MS18153	UNF-2A	1/4 thru 1	0.375 to 5.0 1.25 to 6.0	Alloy-Steel, Grade 8	150	Drilled for Lockwire

Table 556-10-6 FF-S-85 HEXAGON-HEAD CAPSCREWS - Continued

Dimensional Standard	Thread Type	Thread diameter (in.)	Length* (in.)	Material	Tensile Strength (ksi)	Remarks
#MS18154#	UNC-2A					
MS35307	UNC-2A	1/4 thru 1-1/4	0.375 to 5.0 1.25 to 6.0	CRES	70	Undrilled
MS35308	UNF-2A					
MS35309	UNC-2A	1/4 thru 1-1/4	0.375 to 5.0 1.25 to 6.0	Naval Brass	60,000 58,000 (over 1″ dia.)	Undrilled
MS35310	UNF-2A					
MS51095	UNC-2A	1/4 thru 1-1/4	0.375 to 5.0 1.25 to 6.0	Alloy-Steel, Grade 5	120	Drilled for Lockwire
MS51096	UNF-2A					
MS51105	UNC-2A	1/4 thru 1	0.375 to 5.0 1.25 to 6.0	Alloy-Steel, Grade 5	120	Shank Drilled for Cotter Pin
MS51106	UNF-2A					
MS51109	UNC-2A	1/4 thru 1	0.375 to 5.0 1.25 to 6.0	CRES	70	
MS51110	UNF-2A					
#MS90727	UNF-2A	1/4 thru 1-1/2	0.375 to 5.0 1.50 to 6.0	Alloy-Steel, Grade 8	150	Plain or Self-Locking
#MS90728	UNC-2A	1/4 thru 2-1/2	0.375 to 5.0 2.75 to 6.0			L Suffix For Self-Locking

556-10.5.1.1 Selection of Dimensional Standard. Replacement cadmium plated cap screws shall be selected from the NAS 1351 and NAS 1352 standards, when available, rather than from the MS standards. The thread forms on the NAS and MS cap screws differ slightly but are interchangeable as long as the number of threads per inch (designated as coarse or fine) is the same. The reasons for using NAS cap screws for replacement are:

a. A 23-hour bake after plating to provide hydrogen embrittlement relief has been applied to the NAS cap screws for a number of years whereas the 23-hour bake for the MS cap screws is just now being implemented.

b. Some of the MS standards have not been updated to reflect current FF-S-86 requirements.

c. The cadmium plating thickness on the NAS cap screws is .0003 inch versus .0002 inch on the MS cap screws and provides improved corrosion resistance.

d. The NAS cap screw threads have a controlled root radius which provides improved fatigue resistance.

e. The NAS 1351 and NAS 1352 cap screws are listed in MIL-STD-1251 as being preferred for new design, and cancellation of the MS standards in favor of the NAS standards is expected.

556-10.5.1.2 NAS 1351 and NAS 1352 Part Numbers. The NAS 1351 and NAS 1352 part numbers are identified per Table 556-10-7. Using this table it is possible to identify replacements for the MS cadmium plated socket head cap screws listed below. For those MS cap screws marked with an (*), substitution for use in counterbores may not be possible for some sizes due to slightly larger head diameters on the NAS cap screws.

MS16997, MS24677, MS35457* NAS 1352

MS16998, MS21262*, MS24678*, NAS 1351

and MS35458*

NAS 1351 covers fine thread while NAS 1352 covers coarse threads. Each NAS standard covers three materials which are identified in the part number as follows:

- = Alloy steel, 170,000 or 180,000 psi

C = Corrosion resisting steel, 80,000 psi

N = Heat (and corrosion) resisting steel, 160,000 psi

Table 556-10-7 NAS 1351 & NAS 1352 PART NUMBERING SYSTEMS

Table 556–10–7. NAS 1351 & NAS 1352 PART NUMBERING SYSTEMS

NAS 1351 – 8 H 12 P

P — Finish code

Alloy Steel:	P = Cadmium Plate No suffix for Black Oxide
CRES Steel:	P = Cadmium Plate No suffix for Passivate
Heat-Resisting Steel:	S = Silver Plate No suffix for Passivate B = Black Oxide

12 — Length Dash Number indicates length in sixteenths of an inch. Preferred lengths are tabulated in the standard.

H — Type Code

- – = Undrilled Head
- H = Drilled Head (for lockwire)
- LE = Self-Locking Male Threaded Fastener (Optional Type Locking Element in accordance with NAS 1283)
- LL = Self-Locking Male Threaded Fastener (Longitudinal Strip Locking Element, NAS 1283, Type L)
- LN = Self-Locking Male Threaded Fastener (Pellet Locking Element, NAS 1283, Type N)
- LB = Self-Locking Male Threaded Fastener (Patch type Locking Element, NAS 1283, Type P)

8 — Nominal Thread Size Dash Number as tabulated in standard

- 00 to 08 = Nominal Size (for small diameter fasteners)
- 3 to 16 = Nominal diameter in sixteenths of an inch

– — Material Code

- – = Alloy Steel
- C = Corrosion Resisting Steel
- N = Heat Resistant Steel

1351 — Standard No.

- 1351 = Socket Head Capscrew, UNRF–3A Threads
- 1352 = Socket Head Capscrew, UNRC–3A Threads

NAS — National Aerospace Standard

556-10.5.1.3 Authorized Socket Head Cap Screw Substitutions. The following substitutions are authorized for hydraulic system components:

a. NAS 1351 and NAS 1352 cadmium plated high-strength alloy steel socket head cap screws for the equivalent cadmium and zinc plated cap screws identified in 556-10.5.1.2.

b. When rusting of high-strength, alloy steel cap screws is a problem, substitution of heat- (and corrosion resisting) cap screws per NAS 1351 and NAS 1352 is authorized. (The slightly lower strength is considered to have minimal impact on shock resistance.) The part number for the heat resisting cap screw is the same as for alloy steel except that the - in the part number is replaced by an N. This letter N will also be found on the head of the fastener for identification purposes. In addition, the last letter of the part number suffix may change to designate a surface finish change. Silver plated, heat resisting cap screws should be used to minimize the possibility of galling with thread inserts or metal of similar hardness. The silver plate is designated by the suffix letter S as shown in the example below. As an alternative, passivated cap screws can be used if a dry film lubricant per MIL-L-40160 is applied by the manufacturer or locally before installation. In this case no suffix letter applies.

c. Replacement of MS corrosion resisting (CRES) cap screws with NAS 1351 and NAS 1352 corrosion resisting (CRES) cap screws of the same size.

d. Cap screws used in submarine hydraulic systems identified by size and Electric Boat/General Dynamics (EB/GD) specification 1890 and carrying identification marks S-130 (alloy steel, 160,000 psi minimum tensile strength) and S-150 (alloy steel, 170,000 psi minimum tensile strength) can be replaced by equivalent size NAS 1351 and NAS 1352 cap screws of either cadmium plated alloy steel or heat resisting steel. Example: Replace MS24678-57 cadmium plated alloy steel cap screw Reference to MS24678 or logistic system technical data for MS24678-57 indicates this cap screw is 1.000 inch long with 1/2-20 UNF-3A threads. Using Table 556-10-7, the equivalent NAS cap screw is: NAS1351-8H16P = .500-20 UNRF-3A socket-head cap screw, alloy steel, drilled head, 1.00 inch long, cadmium plated The equivalent NAS heat and corrosion resisting fastener is: NAS1351N8H16S = .500-20 UNRF-3A socket head cap, heat resisting steel, drilled head, 1.00 inch long, silver plated

556-10.5.1.4 Socket Head Cap Screw Substitutions Requiring NAVSEA Approval. The following substitutions require specific NAVSEA approval.

a. Substitution of lower strength, Corrosion-Resistant Steel (CRES) cap screws for higher strength alloy or heat resisting steel cap screws in applications subject to MIL-S-901 hi-shock requirements. For applications not subject to MIL-S-901 shock requirements, verify cap screw suitability using the procedure illustrated in paragraph 556-10.3.1.1 to find required torque. The lower strength cap screw may be used only if the torque required does not exceed that recommended in Table 556-10-1 for the CRES cap screws.

b. Substitution of a black oxide coated alloy steel fastener for one of any other material or coating except for temporary emergency use.

556-10.5.2 INTERNAL WRENCHING BOLTS. These fasteners are similar to the socket head cap screws identified above but have unique characteristics which prevent their direct substitution for socket head cap screws. The procurement specifications for these bolts are NAS 159 and MIL-B-7838. Only MIL-B-7838 fasteners shall be used for new design and are preferred for replacement. The dimensional standards for the bolts are NAS144 thru 158 and MS20004 thru MS20024. NAVSEA is developing a new dimensional standard, MIL-B-7838/1, with a longer portion of the shank threaded to use in application where the bolts are screwed into a component body or manifold.

CAUTION

When using NAS 144 thru 158 and MS20004 thru MS20024 bolts, verify that threaded length of the bolt is satisfactory for the application. M7838/1 bolts have longer threads.

All these bolts have a relatively large radius between the head and shank for better fatigue resistance which precludes installation with standard flat washers.

CAUTION

Installation of these bolts shall be made only with the use of a counter sunk washer. Use of a standard washer can induce high stresses at the radius between the head and shank which will result in bolt failure. Therefore, the bolts must be installed with one of the countersunk washers identified in paragraph 556-10.5.5.

556-10.5.2.1 Distinguishing Internal Wrenching Bolts from Socket Head Cap Screws. Because the internal wrenching bolts require countersunk washers it is very important to be able to readily distinguish them from socket head cap screws. The cap screws have cylindrical heads while the internal wrenching bolt heads are in the shape of a truncated cone, i.e., the side of the head is tapered with a larger diameter at the bottom of the head than at the top of the head.

556-10.5.2.2 Identification Marking of Internal Wrenching Bolts. The only identification marking on the NAS bolts is a ″R″ to indicate rolled threads, although some may be marked with a part number. The MIL-B-7838 bolts are marked with the part number. Currently, MIL-B-7838 stock contains only bolts with part numbers in accordance with MS20004 through MS20024. However, NAVSEA is initiating action which will result in bolts identified as M7838/1 followed by dash numbers indicating diameter and length. (See paragraph 556-10.5.2.3.)

556-10.5.2.3 Restrictions on the Use of Internal Wrenching Bolts. The following restrictions apply to use of internal wrenching bolts:

a. The bolts shall be used only with one of the countersink washers identified in paragraph 556-10.5.5. The countersink in the washer must face the head of the bolt.

b. Except for emergency use, internal wrenching bolts shall not be substituted for socket head or hex head cap screws unless approved by NAVSEA. In general, approval will be limited to applications where drawings and other technical documentation are revised to reflect the change. Another reason for NAVSEA approval is that many of the currently available internal wrenching bolts are not threaded for a sufficient length for use in many hydraulic components, particularly where the bolts are threaded into inserts in aluminum valve bodies. NAVSEA is developing a specification sheet, MIL-B-7838/1, which will provide for internal wrenching bolts suitable for use with inserts up to two bolt diameters in length.

556-10.5.3 HEXAGON-HEAD CAP SCREWS. Hexagon-head are covered by FF-S-85. For military applications, the cap screws must be in accordance with an applicable Military Standard. Table 556-10-6 provides a list of the applicable dimensional standards. When identifying replacement cap screws be sure that the replacement is as strong as the original. If the strength of the original cannot be determined, select a replacement of the same material with the highest strength. Although some of the military standards in Table 556-10-6 have been superseded by ANSI B18.2.1, replacement cap screws can be ordered from the supply system by either the superseded MS numbers or by the ANSI B18.2.1 part identifying numbers. The cancellation notices provide a cross reference between the MS and ANSI part numbers.

556-10.5.3.1 ANSI B18.2.1 Part Numbering System. The part numbering system is fully described in the Supplement to ANSI B18.2.1, Bolts and Screws, Inch Series. B1821BH050C125N is the part number for a 1/2 inch diameter hexagon head, zinc coated alloy steel cap screw with coarse threads and 1-1/4 inches long. To understand this part number, break it down into its elements and examine each element:

B1821 B H 050 C 125 N

Document identifier:
B1821 stands for ANSI B18.2.1

Material and Finish:
B is alloy steel Grade 8 with zinc coating A is alloy steel Grade 8 with cadmium plating

Fastener Configuration:
H stands for Hexagon Head

Nominal Diameter:
050 is diameter in 100ths of an inch (.50)

Thread Designation:
C is UNC thread form (coarse)
F is UNF thread form (fine)

Nominal Length:
125 is the length in 100ths of an inch (1.25)

Special Features Code:
N=None
D=Drilled head for lockwire
L=Self-locking
C=Drilled head and self-locking

556-10.5.4 REPORTING FASTENER FAILURES. If defective fastener hardware is received from the supply system it is important that a Quality Deficiency Report (Form SF368) be filed so that action can be taken to purge the system of the defective fasteners and prevent additional failures. In addition, NAVSEA has requested that all Navy shipyards and Type Commanders report the failure of all FF-S-86 steel socket head cap screws. The failure report shall include (if known) metallurgical analysis on mode of failure, length of service, quantity failed, fastener part number, National Stock Number, fastener marking and manufacturer, ship, system component identification or part number, how and when failure was discovered. If unable to provide matallurgical analysis, retain failed cap screw and notify NAVSEA 56W16 that you require instructions for forwarding the cap screw for analysis.

556-10.5.5 IDENTIFICATION OF REPLACEMENT WASHERS. The procedures for identifying replacement fasteners are, in general, applicable to identifying replacement washers. MIL-STD-1764, **Washers, Preferred for Design, Listing of** lists many different types of washers and includes drawings, part numbers and dimensions which will aid in identifying washers for both new design and replacement. Table 556-10-8 identifies the flat and countersunk washer part numbers most often applicable to hydraulic equipment. Only cadmium plated steel washers are included in the table. **Note: Do not use cadmium or zinc plated washers or fasteners in the internals of hydraulic components.** (See paragraph 556-1.2.1) For washers of aluminum, brass, CRES and other coatings, refer to MS15795, AN960 and MIL-STD-1764. MIL-STD-1764 lists 20 standards for round flat washers of various materials and coatings.

Table 556-10-8 PART NUMBERS FOR COMMONLY USED ROUND WASHERS

Thread Size	Alloy Steel - Cadmium Plate		Carbon Steel - Cadmium Plate Flat	
	Countersunk	Plain (flat) #	Part No.	(Thickness)*
No. 6			AN960-6	.032
No. 8			AN960-8	.032
No. 10			AN960-10	.063
1/4	MS20002C4	MS20002-4	AN960-416	.063
5/16	MS20002C5	MS20002-5	AN960-516	.063
3/8	MS20002C6	MS20002-6	AN960-616	.063
7/16	MS20002C7	MS20002-7	AN960-716	.063
1/2	MS20002C8	MS20002-8	AN960-816	.063
9/16	MS20002C9	MS20002-9	AN960-916	.063
5/8	MS20002C10	MS20002-10	AN960-1016	.063
3/4	MS20002C12	MS20002-12	AN960-1216	.090
7/8	MS20002C14	MS20002-14	AN960-1416	.090
1	MS20002C16	MS20002-16	AN960-1616	.090
1-1/8	MS20002C18	MS20002-18	AN960-1816	.090
1-1/4	MS20002C20	MS20002-20	AN960-2016	.090
1-3/8	MS20002C22	MS20002-22		
1-1/2	MS20002C24	MS20002-24		

556-10.5.5.1 Countersunk Washers (Single Surface). Countersunk washers must be used with the internal wrenching bolts described in paragraph 556-10.5.2. The countersunk face of the washer must be placed under the bolt head to prevent the development of damaging stresses at the head-to-shank fillet radius of the bolt. Table 556-10-8 contains a list of part numbers for both flat (plain) and countersunk washers (one surface) to MS20002 (Alloy steel, cadmium plate). CRES countersunk washers (one surface) are available to NAS1587.

556-10.5.5.2 Countersunk Washers (Two Surfaces). Washers with both surfaces countersunk are available to part numbers in accordance with MS9482 (Steel-Diffused nickel cadmium plate), MS9768 (CRES), MS14155 (Alloy steel, cadmium plate) and MS14177 (Alloy steel, cadmium plate). The washers with both surfaces countersunk are normally thicker than washers with only a single countersunk surface. Therefore, the two surface countersunk washers should not be substituted for thinner washers without an engineering analysis that sufficient thread engagement will be maintained. The double countersunk washers may sometimes be substituted when the available replacement fastener is slightly longer than desired since the increased thickness may prevent bottoming of the fastener in a tapped hole.

556-10.5.5.3 Lockwashers. Although lockwashers may be encountered, the use of flat washers with self-locking nuts, self-locking fasteners, self-locking inserts or thread sealants such as MIL-S-22473 anaerobic compounds is preferred. Use the procedures in paragraph 556-10.5.5.3 for identification of replacement lockwashers.

556-10.6 SAFETY OR LOCKWIRING OF FASTENERS

556-10.6.1 The use of fasteners drilled for safety or locking wire is not to be taken as a requirement for lockwiring. The drilling of fasteners for lockwiring is a standardization technique that is being adopted to reduce the types of fasteners required. The practice of lockwiring has several pros and cons which must be considered for each application.

a. While lockwiring does tend to prevent loosening of fasteners, the proper torquing of fasteners is of primary importance in ensuring a proper installation which will not loosen. Periodic torquing of fasteners is a good maintenance practice which is discouraged by the installation of lockwire. Similarly, the lockwiring of vents and drains discourages periodic venting of air and draining of water from a hydraulic system. In some cases, components assemblies are lockwired primarily to discourage disassembly and to provide an indication that the component has been disassembled.

b. Fasteners should be lockwired where required by component assembly or installation drawings. In addition, other fasteners may be lockwired where additional assurance is considered necessary to prevent a fastener from working loose and creating a serious safety hazard. For lockwiring procedures see NSTM Chapter 075, Threaded Fasteners.

c. In general, self-locking fasteners may be used where lockwiring is specified. When substituting self-locking fasteners for fasteners with lockwire, the following guidance must be followed:

   1 Unless specifically approved, self-locking fasteners will be limited to the standard fasteners identified in Table 556-10-5, Table 556-10-6 and Table 556-10-7.

   2 Substitution shall be limited to fasteners of the same tensile strength unless the substitution is in accordance with substitutions permitted by this chapter.

   3 To ensure proper torquing, all fasteners performing the same function shall be the same. For example, all four bolts on a flange shall be the same. Lockwiring two bolts and using two self-locking bolts is not acceptable.

556-10.7 THREAD INSERTS

556-10.7.1 GENERAL. The term thread insert refers to a threaded piece inserted into a tapped hole to form standard size internal threads.

556-10.7.2 APPLICATIONS FOR THREAD INSERTS. Thread inserts are used to restore damaged threads in castings or forgings and to protect and strengthen tapped threads in light materials such as plastic and wood and low shear strength metals such as aluminum. Typically thread inserts are used in tapped holes for bolting flanges to aluminum valve bodies and valve bodies to aluminum subplates. In repair applications, inserts are used to restore damaged tapped holes or existing damaged inserts previously installed in tapped holes.

556-10.7.3 TYPES OF THREAD INSERTS. Thread inserts used in Naval applications are of two approved types - helical-coil in accordance with MIL-I-8846 and thin wall in accordance with MIL-I-45932. The helical-coil insert (Figure 556-10-2) consists of a diamond-shaped wire wound in the shape of a helical-coil. The outside diameter of this coil is designed to mate with a drilled and tapped hole sized for each application. The thin wall insert (Figure 556-10-3) is a bushing with a standard size internal thread and an external thread of a larger standard size for which the mating hole has been drilled and tapped. The helical-coil insert is held in place by the natural spring action of the coil. The thin wall insert is held in place by expanding the upper two external threads which are serrated to dig into a prepared portion of the hole. Variations are available for both types of inserts with regard to internal thread size and class, internal thread locking features, external locking features to positively retain the inserts, length of inserts, oversized inserts to simplify repair applications, and insert materials.

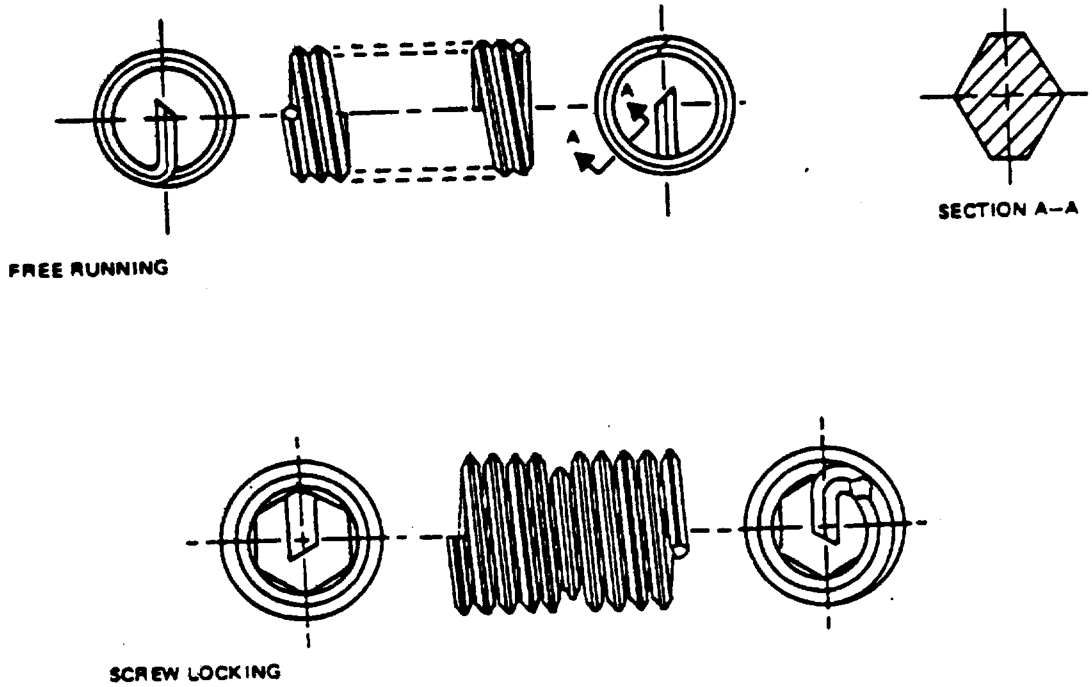


Figure 556-10-2 Helical-Coil Inserts

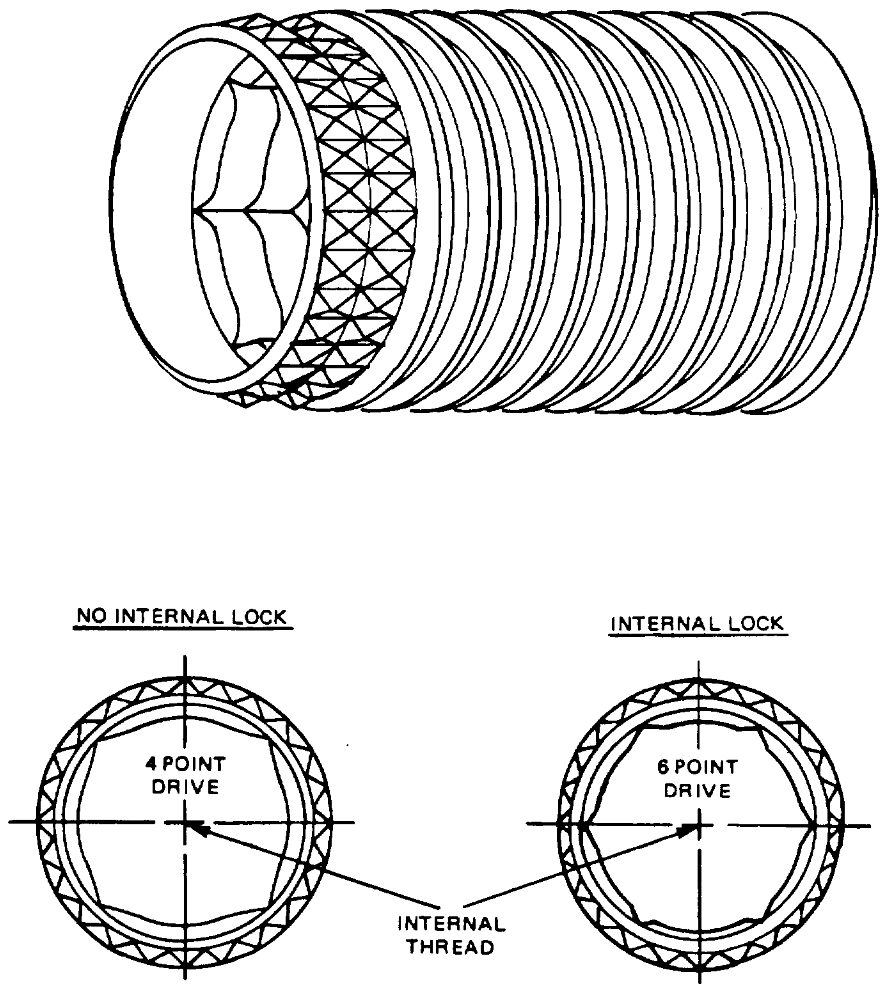


Figure 556-10-3 Typical Thin Wall Inserts

556-10.7.4 HELICAL-COIL THREAD INSERTS. The purpose of the following paragraph on helical-coil inserts is to provide a basic knowledge and general instructions on the use of this type insert, as well as the necessary tools and repair kits needed to repair parts with worn or stripped threads. Helical-coil thread inserts are precision formed coils of diamond-shaped wire used as screw thread bushings. They are available in unified coarse, unified fine, taper pipe, 14 millimeter and 18 millimeter metric thread sizes. The installation process is simple and requires three basic steps: drilling, tapping, and installing; however, it is necessary to have the correct size drills, taps, inserts, and special tools (Figure 556-10-4). Identification of all of these parts to ensure the correct combination is available for any given installation is beyond the scope of this manual. Thorough instructions are provided in manufacturer's literature as well as in repair kits for a specific thread size and master kits containing several sizes of inserts, taps, and tools. Repair kits, individual inserts, and special taps and tools are available in the stock system for popular thread sizes. Major manufacturers of helical-coil inserts are Heli-Coil products for **Heli-Coil** inserts and Microdot products for **Permathread** inserts. Activities involved in the installation of helical-coil inserts should obtain a copy of technical manual **General Installation of Heli-Coil Inserts** , U.S. Air Force T.O. 44H1-1-117, NAVWEPS 02-1-19.

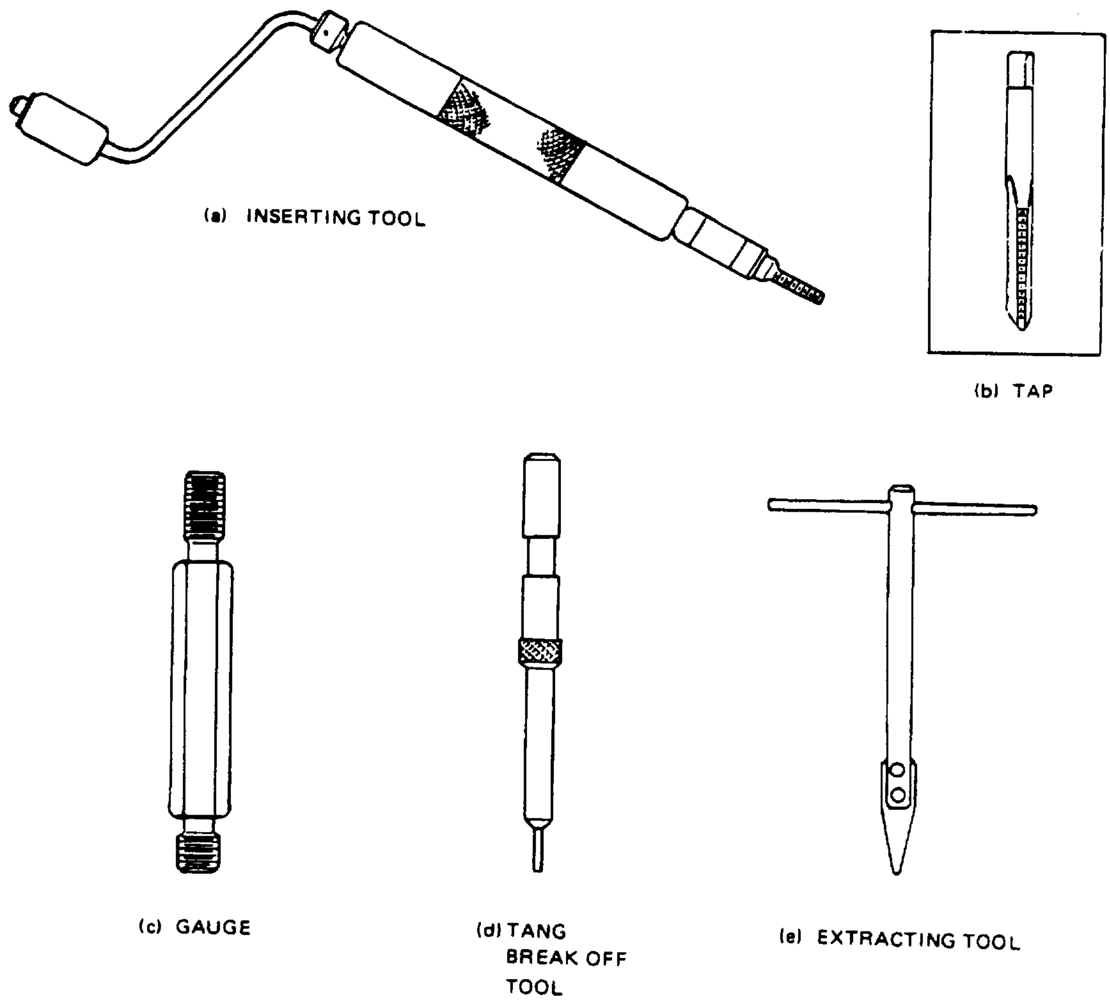


Figure 556-10-4 Typical Helical-Coil Insert Repair Tools

556-10.7.4.1 Selection of Insert. The thread size of the removed fastener will determine the size of insert and repair kit required. The repair kit contains the thread tap for the insert's outside diameter, several stainless steel inserts of 1-1/2 nominal diameter length, an installation tool, and instructions. If the insert length required is different from those supplied in the kits (Table 556-10-9), inserts can be procured separately from the manufacturer or the stock system. (See Table 556-10-10 through Table 556-10-13) A partial listing of available helical-coil inserts is also provided in the Afloat Shopping Guide, Class 5340. Determine from the extracted insert whether it was free running or of the screw-locking type. Even in a partially mutilated state, the grip coil of the screw-locking insert can be identified by its non-circular (polygonal) configuration in the middle section of the insert. Replace the screw-locking insert only by a screw-locking insert. Screw-locking inserts are usually colored red for identification purposes. Repair kits contain inserts which are usually either all free-running or all locking types. In determining insert size, measuring the length and diameter of the insert in its free state is not an adequate indication of those dimensions of the installed insert. Therefore, the old insert, damaged or otherwise, cannot be measured to determine the full thread depth of the hole. The tapped hole is used to determine full thread depth. When ordering Metric series inserts or repair kits, coarse or fine, also state both diameter and pitch of the threads, such as M18X2.5 (coarse) or M18X1.5 (fine).

Table 556-10-9 NATIONAL STOCK NUMBER LISTING MODULAR FIELD SERVICE THREAD REPAIR PACKS

Unified Coarse			Unified Fine		
Thread Size	Heli-Coil Part Number	NSN 5180-00-	Thread Size	Heli-Coil Part Number	NSN 5180-00-
2-56	4131-02-1		3-56	4132-03-1	
3-48	4131-031-1		4-48	4132-041-1	
4-40	4131-04-1	054-7506			
5-40	4131-05-1	054-7524			
6-32	4131-06-1	054-7507	6-40	4132-06-1	054-7525
8-32	4131-2-1	935-0730	8-36	4132-2-1	
10-24	4131-3-1	935-0731	10-32	4132-3-1	935-0735
12-24	4131-1-1	054-7526			
1/4-20	4131-4-1	935-0732	1/4-28	4132-4-1	935-0736
5/16-18	4131-5-1	935-0733	5/16-24	4132-5-1	935-0737
3/8-16	4131-6-1	935-0734	3/8-24	4132-6-1	935-0738
7/16-14	4131-7-1	054-7503	7/16-20	4132-7-1	935-9739
1/2-13	4131-8-1	051-5024	1/2-20	4132-8-1	054-7505
9/16-12	4131-9-1	059-4829	9/16-18	4132-9-1	054-7516
5/8-11	4131-10-1	054-7514	5/8-18	4132-10-1	054-7512
3/4-10	4131-12-1	051-5025	3/4-16	4132-12-1	054-7513
7/8-9	4131-14-1	054-7515	7/8-14	4132-14-1	054-7519
1-8	4131-16-1	051-5026	1-12	4132-16-1-1	054-7520
			1-14	4132-16-1	054-7521
1 1/8-7	4131-18-1	054-7527	1 1/8-12	4132-18-1	054-7522
1 1/4-7	4131-20-1	054-7528	1 1/4-12	4132-20-1	054-7523
1 3/8-6	4131-22-1	051-5027	1 3/8-12	4132-22-1	051-5028
1 1/2-6	4131-24-1	051-5030	1 1/2-12	4132-24-1	054-7529
8-32	4146-2-1	832-4906	10-32	4147-3-1	832-4911
10-24	4146-3-1	832-4907	1/4-28	4147-4-1	832-4912
1/4-20	4146-4-1	832-4907	5/16-24	4147-5-1	832-4913
5/16-18	4146-5-1	089-8132	3/8-24	4147-6-1	832-4914
3/8-16	4146-6-1	832-4910	7/16-20	4147-7-1	832-4915

Table 556-10-10 PART NUMBERS FOR HELICAL - COIL INSERTS FREE - RUNNING COARSE THREAD (1-1/2 AND 2 DIAMETER LENGTHS)

Thread Size	Length Inches	M.S. Part Number	National Stock Number	Heli-Coil Part Number	Perma-Thread Part Number
2-56	.129	122135	5340-00-997-6886	1185-02CN-0129	208-C02-0129
2-56	.172	122175	5340-00-834-8372	1185-02CN-0172	208-C02-0172
3-48	.148	122155	----	1185-013CN-0148	208-C03-0148
3-48	.198	122195	----	1185-013CN-0198	208-C03-0198
4-40	.168	122116	5340-00-842-5920	1185-04CN-0168	208-C04-0168
4-40	.224	122156	5340-00-825-8215	1185-04CN-0224	208-C04-0224
5-40	.188	122117	5340-00-619-3138	1185-05CN-0188	208-C05-0188
5-40	.250	122157	----	1185-05CN-0250	208-C05-0250
6-32	.207	122118	5340-00-682-1520	1185-00CN-0207	208-C06-0207
6-32	.276	122158	5340-00-825-4826	1185-00CN-0276	208-C06-0276
8-32	.246	122119	5340-00-297-3841	1185-2CN-0246	208-C08-0246

Table 556-10-10 PART NUMBERS FOR HELICAL - COIL INSERTS FREE - RUNNING COARSE THREAD (1-1/2 AND 2 DIAMETER LENGTHS) - Continued

Thread Size	Length Inches	M.S. Part Number	National Stock Number	Heli-Coil Part Number	Perma-Thread Part Number
8-32	.328	122159	5340-00-290-4509	1185-2CN-0328	208-C08-0328
10-24	.285	122120	5340-00-597-3304	1185-3CN-0285	208-C1-0285
10-24	.380	122160	5340-00-290-4478	1185-3CN-0380	208-C1-0380
1/4-20	.375	122121	5340-00-290-4481	1185-4CN-0375	208-C4-0375
1/4-20	.500	122161	5340-00-286-2458	1185-4CN-0500	208-C4-0500
5/16-18	.469	122122	5340-00-290-4521	1185-5CN-0469	208-C5-0469
5/16-18	.625	122162	5340-00-290-4520	1185-5CN-0625	208-C5-0625
3/8-16	.562	122123	5340-00-290-4518	1185-6CN-0562	208-C6-0562
3/8-16	.750	122163	5340-00-990-7175	1185-6CN-0750	208-C6-0750
7/16-14	.656	122124	5340-00-290-4506	1185-7CN-0656	208-C7-0656
7/16-14	.875	122164	5340-00-290-5638	1185-7CN-0875	208-C7-0875
1/2-13	.750	122125	5340-00-290-4504	1185-8CN-0750	208-C8-0750
1/2-13	1.000	122165	5340-00-990-7158	1185-8CN-1000	208-C8-1000
9/16-12	.844	122126	5340-00-290-4493	1185-9CN-0844	208-C9-0844
9/16-12	1.125	122166	5340-00-993-7245	1185-9CN-1125	208-C9-1125
5/8-11	.938	122127	5340-00-290-4494	1185-10CN-0938	208-C10-0938
5/8-11	1.250	122167	5340-00-807-3488	1185-10CN-1250	208-C10-1250
3/4-10	1.125	122128	5340-00-045-2812	1185-12CN-1125	208-C12-1125
3/4-10	1.500	122168	5340-00-721-8356	1185-12CN-1500	208-C12-1500
7/8-9	1.312	122129	5340-00-682-2216	1185-14CN-1312	208-C14-1312
7/8-9	1.750	122169	5340-00-664-8332	1185-14CN-1750	208-C14-1750
1-8	1.500	122130	5340-00-530-5603	1185-16CN-1500	208-C16-1500
1-8	2.000	122170	5340-00-998-7246	1185-16CN-2000	208-C16-2000
1 1/8-7	1.688	122131	5340-00-059-2372	1185-18CN-1688	208-C18-1688
1 1/8-7	2.250	122171	5340-00-059-2373	1185-18CN-2250	208-C18-2250
1 1/4-7	1.875	122132	5340-00-059-2375	1185-20CN-1875	208-C20-1875
1 1/4-7	2.500	122172	5340-00-619-8208	1185-20CN-2500	208-C20-2500
1 3/8-6	2.062	122133	5340-00-059-2377	1185-22CN-2062	208-C22-2062
1 3/8-6	2.750	122173	5340-00-059-2378	1185-22CN-2750	208-C22-2750
1 1/2-6	2.250	122134	5340-00-059-2380	1185-24CN-2250	208-C24-2275
1 1/2-6	3.000	122174	5340-00-059-2381	1185-24CN-3000	208-C24-3000

Table 556-10-11 PART NUMBERS FOR HELICAL - COIL INSERTS, FREE-RUNNING, FINE THREAD (1-1/2 AND 2 DIAMETER LENGTHS

Thread Size	Length Inches	M.S. Part Number *	National Stock Number	Heli-Coil Part Number	Perma-Thread Part Number
3-56	.148	124710		1191-03CN-0148	208-F03-0148
3-56	.198	124750		1191-03CN-0198	208-F03-0198
4-48	.168	124711		1191-041CN-0168	208-F04-0168
4-48	.224	124751		1191-041CN-0224	208-F04-0224
6-40	.207	124693	5340-00-982-7842	1191-06CN-0207	208-F06-0207

Table 556-10-11 PART NUMBERS FOR HELICAL - COIL INSERTS, FREE-RUNNING, FINE THREAD (1-1/2 AND 2 DIAMETER LENGTHS - Continued

Thread Size	Length Inches	M.S. Part Number *	National Stock Number	Heli-Coil Part Number	Perma-Thread Part Number
6-40	.276	124733	5340-00-045-3555	1191-06CN-0276	208-F06-0276
8-36	.246	124694	5340-00-141-6688	1191-2CN-0246	208-F08-0246
8-36	.328	124734		1191-2CN-0328	208-F08-0328
10-32	.285	124695	5340-00-597-3302	1191-3CN-0285	208-F1-0285
10-32	.380	124735	5340-00-290-4480	1191-3CN-0380	208-F1-0380
1/4-28	.375	124696	5340-00-291-3484	1191-4CN-0375	208-F4-0375
1/4-28	.500	124736	5340-00-290-4497	1191-4CN-0500	208-F4-0500
5/16-24	.469	124697	5340-00-291-3495	1191-5CN-0469	208-F5-0469
5/16-24	.625	124737	5340-00-514-2321	1191-5CN-0625	208-F5-0625
3/8-24	.562	124698	5340-00-291-3492	1191-6CN-0562	208-F6-0562
3/8-24	.750	124738	5340-00-990-7159	1191-6CN-0750	208-F6-0750
7/16-20	.656	124699	5340-00-634-7860	1191-7CN-0656	208-F7-0656
7/16-20	.875	124739	5340-00-290-4511	1191-7CN-0875	208-F7-0875
1/2-20	.750	124700	5340-00-291-3448	1191-8CN-0750	208-F8-0750
1/2-20	1.000	124740	5340-00-290-4513	1191-8CN-1000	208-F8-1000
9/16-18	.844	124701	5340-00-291-3487	1191-9CN-0844	208-F9-0844
9/16-18	1.125	124741	5340-00-200-7223	1191-9CN-1125	208-F9-1125
5/8-18	.938	124702	5340-00-530-7948	1191-10CN-0938	208-F10-0938
5/8-18	1.125	124742	5340-00-597-5157	1191-10CN-1250	208-F10-1256
3/4-16	1.125	124703	5340-00-655-7971	1191-12CN-1125	208-F12-1125
3/4-16	1.500	124743	5340-00-200-7222	1191-12CN-1500	208-F12-1500
7/8-14	1.312	124704	5340-00-045-2848	1191-14CN-1312	208-F14-1312
7/8-14	1.750	124744	5340-00-754-2151	1191-14CN-1750	208-F14-1750
1-12	1.500	124691	5340-00-052-2662	1191-161CN-1500	208-F16-1000
1-12	2.000	124731	5340-00-044-4970	1191-161CN-2000	208-F16-2000
1 1/8-12	1.688	124706	5340-00-846-7828	1191-18CN-1688	208-F18-1688
1 1/8-12	2.250	124746	5340-00-059-2386	1191-18CN-2250	208-F18-2250
1 1/4-12	1.875	124707	5340-00-558-3435	1191-20CN-1875	208-F20-1875
1 1/4-12	2.500	124747	5340-00-059-2385	1191-20CN-2500	208-F20-2500
1 3/8-12	2.062	124708	5340-00-059-2383	1191-22CN-2062	208-F22-2062
1 3/8-12	2.750	124748	5340-00-059-2382	1191-22CN-2750	208-F22-2750
1 1/2-12	2.250	124709	5340-00-059-2389	1191-24CN-2250	208-F24-2250
1 1/2-12	3.000	124749	5340-00-059-2388	1191-24CN-3000	208-F24-3000

Table 556-10-12 PART NUMBERS FOR HELICAL - COIL INSERTS, SCREW LOCKING, COARSE THREAD (1-1/2 AND 2 DIAMETER LENGTHS)

Thread Size	Length Inches	MS21209 Dash Number *	National Stock Number	Heli-Coil Part Number	Perma-Thread Part Number
2-56	.129	----	5340-00-885-7893	3585-02CN-0129	209-C02-0129

Table 556-10-12 PART NUMBERS FOR HELICAL - COIL INSERTS, SCREW LOCKING, COARSE THREAD (1-1/2 AND 2 DIAMETER LENGTHS) - Continued

Thread Size	Length Inches	MS21209 Dash Number *	National Stock Number	Heli-Coil Part Number	Perma-Thread Part Number
2-56	.172	----	5340-00-462-4226	3585-02CN-0172	209-C02-0172
3-48	.148	----	5340-00-886-6312	3585-031CN-0148	209-C03-0148
3-48	.198	----	----	3585-031CN-0198	209-C03-0198
4-40	.168	MS21209-C0415	5340-00-631-7894	3585-04CN-0168	209-C04-0168
4-40	.224	MS21209-C0420	5340-00-827-4024	3585-04CN-0224	209-C04-0224
5-40	.188	MS21209-C0515	----	3585-05CN-0188	209-C05-0188
5-40	.250	MS21209-C0520	----	3585-05CN-0250	209-C05-0250
6-32	.207	MS21209-C0615	5340-00-815-4930	3585-06CN-0207	209-C06-0207
6-32	.276	MS21209-C0620	5340-00-558-8826	3585-06CN-0276	209-C06-0276
8-32	.246	MS21209-C0815	5340-00-815-4929	3585-2CN-0246	209-C08-0246
8-32	.328	MS21209-C0820	5340-00-721-6936	3585-2CN-0328	209-C08-0328
10-24	.285	MS21209-C1-15	5340-00-680-3762	3585-3CN-0285	209-C1-0285
10-24	.380	MS21209-C1-20	5340-00-990-8643	3585-3CN-0380	209-C1-0380
1/4-20	.375	MS21209-C4-15	5340-00-754-0837	3585-4CN-0375	209-C4-0375
1/4-20	.500	MS21209-C4-20	5340-00-721-8352	3585-4CN-0500	209-C4-0500
5/16-18	.469	MS21209-C5-15	5340-00-803-5574	3585-5CN-0469	209-C5-0469
5/16-18	.625	MS21209-C5-20	5340-00-825-6938	3585-5CN-0625	209-C5-0625
3/8-16	.562	MS21209-C6-15	5340-00-754-1976	3585-6CN-0562	209-C6-0562
3/8-16	.750	MS21209-C6-20	5340-00-812-1894	3585-6CN-0750	209-C6-0750
7/16-14	.656	MS21209-C7-15	5340-00-811-9468	3585-7CN-0656	209-C7-0656
7/16-14	.875	MS21209-C7-20	5340-00-723-6775	3585-7CN-0875	209-C7-0875
1/2-13	.750	MS21209-C8-15	5340-00-814-9865	3585-8CN-0750	209-C8-0750
1/2-13	1.000	MS21209-C8-20	5340-00-812-1900	3585-8CN-1000	209-C8-1000
9/16-12	.844	MS21209-C9-15	5340-00-987-0146	3585-9CN-0844	209-C9-0844
9/16-12	1.125	MS21209-C9-20	5340-00-723-6777	3585-9CN-1125	209-C9-1125
5/8-11	.938	MS21209-C1015	5340-00-811-9469	3585-10CN-0938	209-10-0938
5/8-11	1.250	MS21209-C1020	5340-00-312-1895	3585-10CN-0938	209-10-1250
3/4-10	1.125	MS21209-C1215	5340-00-723-6779	3585-12CN-1125	209-12-1125
3/4-10	1.500	MS21209-C1220	5340-00-800-1676	3585-12CN-1500	209-12-1500
7/8-9	1.312	----	5340-00-724-1920	3585-14CN-1312	209-14-1312
7/8-9	1.750	----	5340-00-724-1919	3585-14CN-1750	209-14-1750
1-8	1.500	----	5340-00-045-0525	3585-16CN-1500	209-16-1500
1-8	2.000	----	----	3585-16CN-2000	209-16-2000
1 1/8-7	1.688	----	----	3585-18CN-1688	209-18-1688
1 1/8-7	2.250	----	----	3585-18CN-2250	209-18-2250
1 1/4-7	1.875	----	----	3585-20CN-1875	209-20-1875
1 1/4-7	2.500	----	----	3585-20CN-2500	209-20-2500
1 3/8-6	2.062	----	----	3585-22CN-2062	209-22-2062
1 3/8-6	2.750	----	----	3585-22CN-2750	209-22-2750
1 1/2-6	2.250	----	----	3585-24CN-2250	209-24-2250
1 1/2-6	3.000	----	----	3585-24CN-3000	209-24-3000
3/4-16	1.125	MS21209-F1215	5340-00-723-6780	3591-12CN-1125	209-F12-1125
3/4-16	1.500	MS21209-F1220	5340-00-836-2941	3591-12CN-1500	209-F12-1500

Table 556-10-12 PART NUMBERS FOR HELICAL - COIL INSERTS, SCREW LOCKING, COARSE THREAD (1-1/2 AND 2 DIAMETER LENGTHS) - Continued

Thread Size	Length Inches	MS21209 Dash Number *	National Stock Number	Heli-Coil Part Number	Perma-Thread Part Number
7/8-14	1.312	MS21209-F1415	5340-00-068-1286	3591-14CN-1312	209-F14-1312
7/8-14	1.750	MS21209-F1420	5340-00-721-5110	3591-14CN-1750	209-F14-1750
1-12	1.500	MS21209-F1615	5340-00-045-0514	3591-161CN-1500	209-F16-1500
1-12	2.000	MS21209-F1620	5340-00-045-0515	3591-161CN-2000	209-F16-2000
1 1/8-12	1.688	MS21209-F1815	----	3591-18CN-1688	209-F18-1688
1 1/8-12	2.250	----	----	3591-18CN-2250	209-F18-2250
1 1/4-12	1.875	MS21209-F2015	----	3591-20CN-1875	209-F20-1875
1 1/4-12	2.500	----	----	3591-20CN-2500	209-F20-2500
1 3/8-12	2.062	MS21209-F2215	----	3591-22CN-2062	209-F22-2062
1 3/8-12	2.750	----	----	3591-22CN-2750	209-F22-2750
1 1/2-12	2.250	MS21209-F2415	----	3591-24CN-2250	209-F24-2250
1 1/2-12	3.000	----	----	3591-24CN-3000	209-F24-3000

Table 556-10-13 PART NUMBERS FOR HELICAL - COIL INSERTS, SCREW LOCKING, FINE THREAD (1- 1/2 AND 2 DIAMETER LENGTHS)

Thread Size	Length Inches	MS21209 Dash Number *	National Stock Number	Heli-Coil Part Number	Perma-Thread Part Number
3-56	.148	----	----	3591-03CN-0148	209-F03-0148
3-56	.198	----	----	3591-03CN-0198	209-F03-0193
4-48	.168	----	----	3591-041CN-0198	209-F04-0168
4-48	.224	----	----	3591-041CN-0224	209-F04-0224
6-40	.207	----	5340-00-754-1207	3591-06CN-0207	209-F06-0207
6-40	.276	----	5340-00-825-1475	3591-06CN-0276	209-F06-0276
8-36	.246	----	----	3591-2CN-9246	209-F08-0246
8-36	.328	----	----	3591-2CN-0328	209-F08-0328
10-32	.285	MS21209-F1-15	5340-00-800-7874	3591-3CN-0285	209-F1-0285
10-32	.380	MS21209-F1-20	5340-00-721-7653	3591-3CN-0380	209-F1-0380
1/4-28	.375	MS21209-F4-15	5340-00-829-2141	3591-4CN-0375	209-F4-0375
1/4-28	.500	MS21209-F4-20	5340-00-721-7498	3591-4CN-0500	209-F4-0500
5/16-24	.469	MS21209-F5-15	5340-00-847-0734	3591-5CN-0469	209-F5-0469
5/16-24	.625	MS21209-F5-20	5340-00-582-7256	3591-5CN-0625	209-F5-0625
3/8-24	.562	MS21209-F6-15	5340-00-680-8768	3591-6CN-0562	209-F6-0562
3/8-24	.750	MS21209-F6-20	5340-00-678-3311	3591-6CN-0750	209-F6-0750
7/16-20	.656	MS21209-F7-15	5340-00-678-3310	3591-7CN-0656	209-F7-0656
7/16-20	.875	MS21209-F7-20	5340-00-619-4227	3591-7CN-0875	209-F7-0875
1/2-20	.750	MS21209-F8-15	5340-00-678-3309	3591-8CN-0750	209-F8-0750
1/2-20	1.000	MS21209-F8-20	5340-00-721-7915	3591-8CN-1000	209-F8-1000
9/16-18	.844	MS21209-F9-15	5340-00-685-0693	3591-9CN-0844	209-F9-0844
9/16-18	1.125	MS21209-F9-20	5340-00-726-8526	3591-9CN-1125	209-F9-1125
5/8-18	.938	MS21209-F1015	5340-00-834-8362	3591-10CN-0938	209-F10-0938

Table 556-10-13 PART NUMBERS FOR HELICAL - COIL INSERTS, SCREW LOCKING, FINE THREAD (1- 1/2 AND 2 DIAMETER LENGTHS) - Continued

Thread Size	Length Inches	MS21209 Dash Number *	National Stock Number	Heli-Coil Part Number	Perma-Thread Part Number
5/8-18	1.250	MS21209-F1020	5340-00-728-9774	3591-10CN-1250	209-F10-1250
3/4-16	1.125	MS21209-F1215	5340-00-723-6780	3591-12CN-1125	209-F12-1125
3/4-16	1.500	MS21209-F1220	5340-00-836-2941	3591-12CN-1500	209-F12-1500
7/8-14	1.312	MS21209-F1415	5340-00-068-1286	3591-14CN-1312	209-F14-1312
7/8-14	1.750	MS21209-F1420	5340-00-721-5110	3591-14CN-1750	209-F14-1750
1-12	1.500	MS21209-F1615	5340-00-045-0514	3591-161CN-1500	209-F16-1500
1-12	2.000	MS21209-F1620	5340-00-045-0515	3591-161CN-2000	209-F16-2000
1 1/8-12	1.688	MS21209-F1815	----	3591-18CN-1688	209-F18-1688
1 1/8-12	2.250	----	----	3591-18CN-2250	209-F18-2250
1 1/4-12	1.875	MS21209-F2015	----	3591-20CN-1875	209-F20-1875
1 1/4-12	2.500	----	----	3591-20CN-2500	209-F20-2500
1 3/8-12	2.062	MS21209-F2215	----	3591-22CN-2062	209-F22-2062
1 3/8-12	2.750	----	----	3591-22CN-2750	209-F22-2750
1 1/2-12	2.250	MS21209-F2415	----	3591-24CN-2250	209-F24-2250
1 1/2-12	3.000	----	----	3591-24CN-3000	209-F24-3000

556-10.7.4.2 Applicable Military Standards. Helical-coil inserts and tools comply with the following standards and specifications. Where standard numbers exist to identify individual parts, such as MS 122121, use these numbers in preference to a manufacturer's part number (See Table 556-10-10 through Table 556-10-13).

1. MS 122076 through MS 122275 - **Insert, Helical-Coil, Coarse Thread (free-running).**
2. MS 124651 through MS 124850 - **Insert, Helical-Coil, Fine Thread (free-running).**
3. MS 21209 **-Insert, Screw Thread, Coarse and Fine (screw-locking).**
4. MS 21208 **- Insert, Screw Thread, Coarse and Fine, Free Running, Helical-Coil, CRES** (Inactive, use MS 122076 thru MS 122275 and MS 124651 thru MS 124850, Included for info. only).
5. MS 33537 **-Tapped Threads and Assembly.**
6. MIL-I-8846 **-Inserts, Screw Threads, Helical-Coil**
7. MIL-T-21309 **-Tools for Inserting and Extracting Helical-Coil Inserts.**
8. MS 9071-18**-1.5mm Boss Thread Dimensions.**
9. AS 1229 **-Insert, Helical-Coil, Stud Locking Performance Standard.**
10. AS 3080 through AS 3083 - **Insert, Helical-Coil (stud locking).**

556-10.7.4.3 Removal of Insert. To remove the insert, place the blade of the extracting tool into the hole so that one edge of the blade is one quarter of a turn from the end of the top wire coil. Strike the head of the tool lightly with a hammer to dig the blade into the tap coil of the insert. Bearing down hard on the handle of the tool, turn it slowly counterclockwise maintaining firm pressure on the handle as the insert backs out. Proper removal of the insert does not damage the parent material. If one or more coils protrude from the hole, cut the wire as close to the surface as possible with wire cutters and then use the extracting tool. Do not reuse inserts once removed, even if the tang is still intact. Whenever an insert is removed, clean the threads of the parent material and inspect for damage. If parent material thread failure is suspected, conduct gauge by inspection. Extracting Tools and Thread Gauges are obtainable from the manufacturers. Because of the hardness of the insert wire, do not attempt to drill out an insert which needs replacement. For removal of inserts from tapped holes 5/16 inch and larger, an alternate method may be used which does not require the special extracting tool. Grasp the top coil of the insert with a pair of long nose pliers. Pulling in the direction away from the hole, gyrate the handle of the pliers to free each coil of the insert individually. Once this procedure has begun, do not relieve the pulling force until the insert is fully removed otherwise the parent material threads may be scored and weakened.

556-10.7.4.4 Installation of Insert. Using the inserting tool contained in the repair kit, follow the step-by-step installation instruction in the kit. Locate the end of the top coil of the installed insert 3/4 to 1-1/12 turns below the end of the threads of the parent material.

556-10.7.4.5 Removal of Insert Tang. To remove the insert tang, place the punch type Tang Removal Tool into the installed insert contacting the tang at the bottom of the hole. The tang is snapped off clean by striking the top of the punch a sharp blow with a hammer. In blind holes, the tang may be removed in the same manner if enough hole depth is provided below the tang with the insert installed. A through hole requires that the insert driving tang be removed. This is not necessary in a blind hole provided the length of the insert permits the tang to clear the bottom of the screw or bolt when the parts are fully assembled. In 9/16 inch and larger bolt diameters, the tang is removed by grasping it firmly with long nose pliers and bending the tang up and down, without disturbing the last coil, breaking it off cleanly at the notch. Retrieve the broken tang and discard.

556-10.7.4.6 Gauging the Threads. Thread gauges are available to check the tapped hole. The installed insert need not be gauged. If the tapped hole is tapped correctly, the installed insert will automatically be within the thread tolerance. The same insert will provide either a Class 2B or a Class 3B fit for Unified Coarse and Unified Fine series threads, depending upon the tapped hole. The insert may not always seat itself when first installed; however, when a bolt or stud is installed and tightened, the insert will conform to the tapped thread.

556-10.7.5 OVERSIZE HELICAL-COIL INSERTS. Oversize inserts, both free-running and screw-locking, are made of slightly larger wire, and are usually identified by yellow markings on the tang and first coil. They are used to repair oversize insert assemblies where an error has occurred in tapping for installation of inserts. Correct out-of-round tapped holes, tapered, and bell mouth conditions by installing oversize inserts. In replacing oversize inserts, follow the same procedure as for standard inserts, and use the same tools as for the standard insert of the same nominal thread size. Oversize repair kits are supplemental to the regular Unified Coarse and Fine Thread repair kits. Each kit includes a special bottoming tap, instructions, and a quantity of inserts. Check final assembly with an appropriate standard thread gauge. If the hole is still oversize, remove insert and repair with a Twinsert.

556-10.7.6 TWINSERTS. Twinserts are proprietary to Heli-Coil products and are special repair inserts for restoring off-center holes, damaged holes, stripped Heli-Coil tapped holes, or damaged Twinserts. A Twinsert assembly (Figure 556-10-5) consists of two inserts; an outer insert which is always a free-running type and an inner insert which may be either a free-running or screw-locking type. Twinserts are installed in an oversize tapped hole produced with a special Twinsert tap. Twinsert kits contain a quantity of 1-1/2 diameter length insert sets, an inserting tool, a Tang Break Off Tool for the outer insert, and a Twinsert tap. Tools to install the inner insert are available in regular UNC or UNF Heli-Coil Thread Repair Kits. Installation instructions and part numbers for all kit components are contained in each tool kit. Two diameter length Twinsert sets may be ordered separately. When replacing Twinsert assemblies, remove the inner insert using the extracting tool for standard helical-coil inserts with the same nominal thread size. Remove the outer insert using the proper extracting tool for that larger size insert or use long-nose pliers as described in paragraph 556-10.7.4.3. Install the outer insert 1/4 to 1/2 turn below the top thread of the tapped hole with the installation tool. Break off the driving tang with the Tang Break Off Tool. Install the inner insert to the position where its top end is flush with the top end of the outer insert (Figure 556-10-6). Installation is done with the installation tool for standard helical-coil inserts of the same thread size. Remove the tang of the inner insert with the Tang Break Off Tool for the standard coil insert of the same thread size.

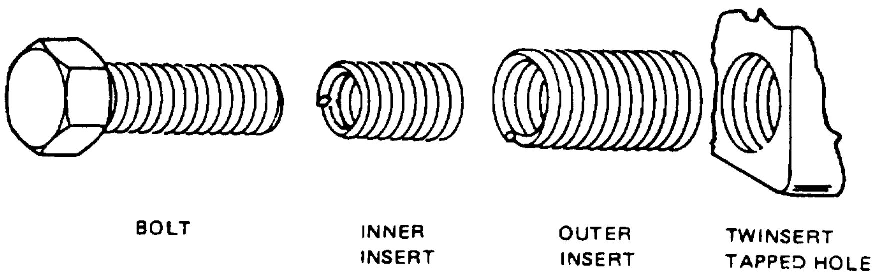


Figure 556-10-5 Heli-Coil Twinsert Assembly

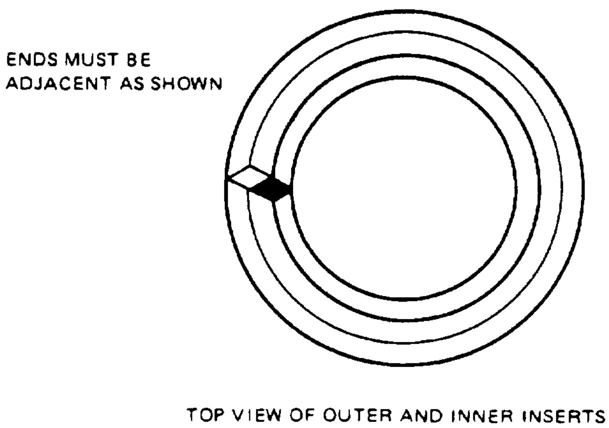


Figure 556-10-6 Twinsert Assembly Top Thread

556-10.7.7 STUD-LOCK INSERTS. Stud-Lock helical-coil inserts (Figure 556-10-7) are an extension of the standard screw-locking insert and are designed to provide higher torque for studs complying with ANSI B 1.12 and FED-STD-H28/23 values for Class 5 interference fit. These inserts are designed to provide these torques with inexpensive Class 3A studs and a minimum thread length to engage the complete length of the insert plus one full turn. When using these studs, no additional lubrication is required. Class 5 interference fit (UNC) studs may be used because of the resilient locking chords. However, the driving torque will be higher than for Class 3A studs but will still conform to ANSI B 1.12 and H28 values when a lubricant such as MIL-T-5544 type grease is applied to the stud. The stud-locking torque is controlled within the proper range for a minimum of three cycles of installing and removing the stud. A new stud may be used for each cycle. In practice, however, the same stud can be reinstalled until the torque falls below minimum, at which point the installation of a new stud will increase the locking torque because the wear is primarily on the stud. Tapped hole preparation is identical to that for standard free-running and screw-locking insert assemblies, the class of fit should be 3B. Installation tools for stud-lock inserts have a reduced pitch diameter to accommodate the deeper grip coil configuration. All other tools are the same as for standard and screw-lock inserts. Individual inserts and repair packs, complete for each size, are available. Inserts for straight studs are dyed green for identification while inserts for step studs (which have the **nut end** one size smaller than the **stud end**) are dyed lavender.

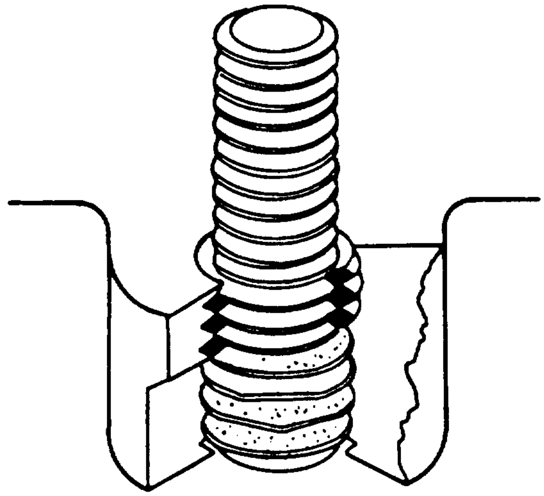


Figure 556-10-7 Assembled Stud-Lock Insert and Stud

556-10.7.8 PIPE THREAD INSERTS. Helical-coil pipe thread inserts are another variation of the standard free-running insert. Before installation, the Pipe Thread Insert is larger in diameter than the tapped hole. When installed, it assumes the configuration of the tapped hole, whether American Standard Taper Pipe Thread, (NPT) Aeronautical National Taper Pipe Thread, (ANPT) or American Standard Coupling Straight Pipe Thread (NPSC). The outward forces resulting from the reduction of the free diameter anchors the insert permanently in place. Appropriate sealing compounds are recommended for pipe thread installations. The same insert is used for all three types of pipe thread assemblies. For NPT and NPSC assemblies, Military Handbook H28 requires gauging the tapped hole with the L1 gauge only. For ANPT assemblies (per MIL-P-7105), a full gauging procedure using Plain Taper Plug, L1 and L3 gauges is required. Complete details on installation is provided with repair kits or separately from the manufacturers upon request. Two types of HELI-COIL Pipe Thread Repair Kits are available. Kit A is recommended for use in repairing ANPT and NPT pipe thread assemblies in which wire thread inserts were not previously installed. This Kit contains a taper reamer, a screw thread insert taper tap (wired), a plain taper plug gauge, an L1 thread plug gauge, an L3 thread plug gauge, an inserting tool, an extracting tool, and a quantity of Pipe Thread Inserts. Kit B is used to repair pipe thread assemblies in which the previously installed HELI-COIL insert is damaged and requires replacement. This Kit contains a tap, an inserting tool, an extracting tool, and a quantity of pipe Thread Inserts. Kit B is used to repair pipe thread assemblies in which the previously installed HELI-COIL insert is damaged and requires replacement. This Kit contains a tap, an inserting tool, an extracting tool, and a quantity of Pipe Thread Inserts.

556-10.7.9 THIN WALL LOCKED-IN INSERTS. Thin wall locked-in inserts are designed and manufactured in accordance with MIL-I-45932/1 and DOD-I-63274/2 (Metric). The top external threads are serrated for external locking against rotation with an internal counterbore in the same region. These serrated threads are swaged into the counterbore for maximum retention. The provision of an internal threads wrenching recess is created by passing a broach directly through the internal threads. Two types of wrenching recesses are used (Figure 556-10-3). A six-point recess serves to identify those parts with an internal thread lock. The four-point recess identifies parts which do not have the internal lock feature. The thin wall of these inserts is made possible by the hi-root form external thread. External thread strength is not diminished by this form change, and it affects installation only to the extent that a slightly oversize tap drill must be provided. The internal thread lock is created by a slight thread deformation at the approximate center of the insert. Thread sizes range from No. 2 to 3/4-inch, unified national coarse and fine, as well as metric 3 to 14 mm. Thin wall inserts are for original design or repair of damaged internal threads. See Figure 556-10-8 for a typical thin wall insert repair kit. In the event the internal thread of the insert is inadvertently cross-threaded or mutilated, the insert may be removed and replaced with the same size part. If the external thread of the insert or the tapped thread in the parent material is damaged, replacement with oversize thin wall swage type inserts is recommended. Engineering data on the inserts is included in the basic specifications, MIL-I-45932 and DOD-I-63274.

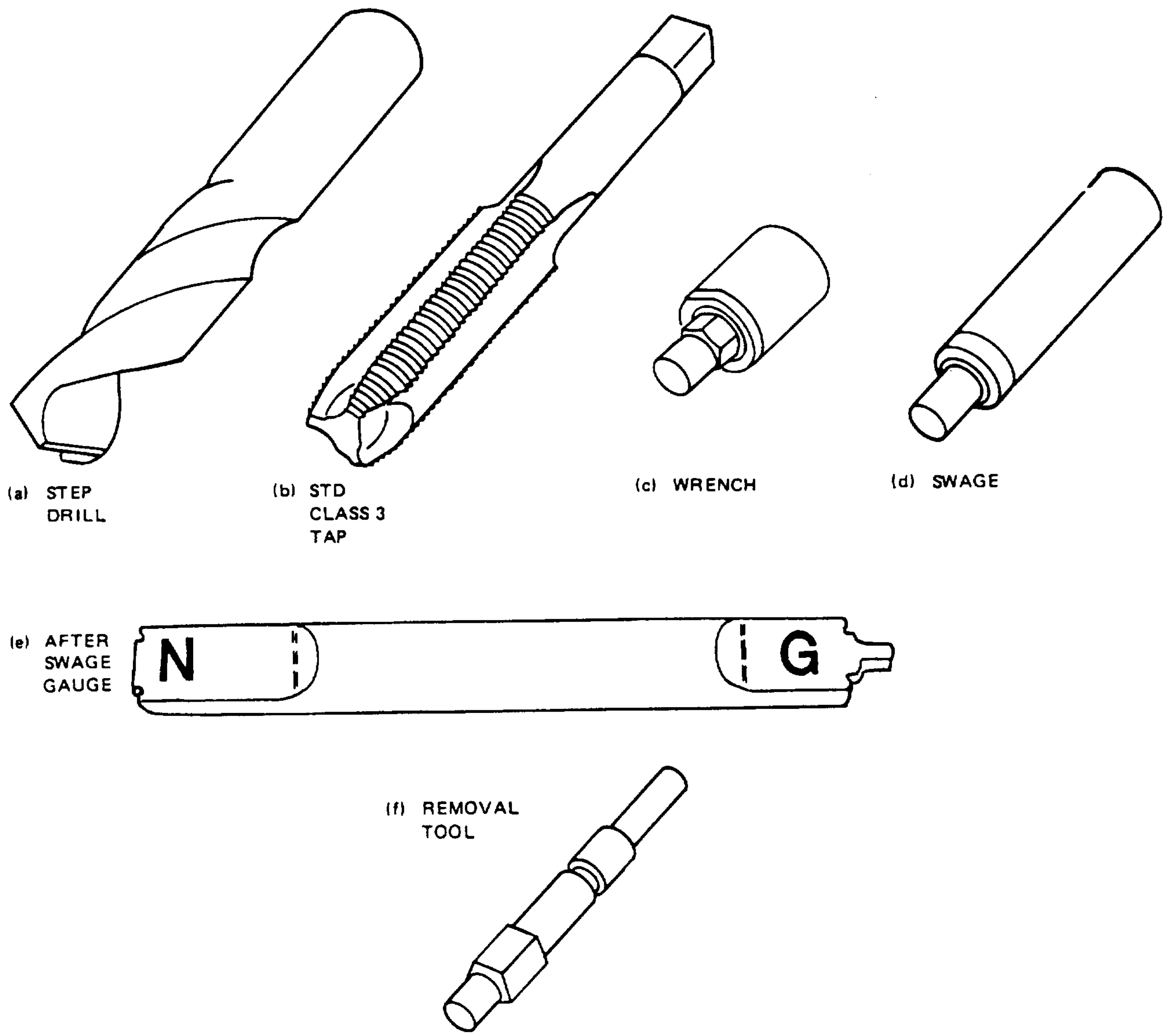


Figure 556-10-8 Typical Thin Wall Insert Repair Kit Tools

556-10.7.9.1 Thin Wall Insert Part Numbers and Materials. Military part numbers are as identified on the specification slash sheets MIL-45932/1, and DOD-I-63274/1 (Metric), also refer to Table 556-10-15 and Table 556-10-16. The most commonly used material is a corrosion-resisting steel, composition 17-4 PH. If the insert is made of any other material the dash number contains the letter A, B, or C to designate of the following materials:

A. Alloy steel, composition 4130, cadmium plated

B. Beryllium copper per AMS 4650

C. Corrosion-resisting steel, composition A-286, silver plated.

For Navy ship applications, use should be limited to one of the corrosion-resisting steels unless otherwise specifically approved. The A-286 corrosion-resisting steel is more costly than 17-4 PH and generally should be used only where a nonmagnetic material or a highly corrosion-resistant material (such as in a sea water environment) is required. An L at the end of a dash number indicates that the insert is of the self-locking variety. Part numbers of some equivalent commercial products are provided in Table 556-10-14. Since all sizes of inserts may not be stocked in the supply system, Table 556-10-14 provides National Stock Numbers for the commonly used 17-4 pH inserts with internal thread locks.

Table 556-10-14 THIN WALL INSERTS, REPAIR KITS, AND NSN'S (THREAD LOCKING, 1-1/2 NO MINAL DIAMETER LENGTH, UNC AND UNF)

Insert Initial Thread Size	**Thin Wall Inserts with Internal Thread Lock***				**Repair Kits****	
	Military Number	**Rosan Number**	**Microdot Number**	**Insert NSN (5340)**	**Rosan Tool Kit**	**Tool Kit NSN >(5180)**
4-40	M45932/1-3L	SR 110L	K8002-04	-00-857-4921	K4-110-110L	-00-178-0056
6-32	M45932/1-5L	SR 142L	K8002-06	-00-864-4958	K4-142-142L	-00-177-8960
8-32	M45932/1-7L	SR 162L	K8002-08	-00-990-9916	K4-162-162L	-00-177-8966
10-24	M45932/1-11L	SR 194L	K8002-1024	-00-971-7615	K4-194-194L	-00-177-8963
1/4-20	M45932/1-15L	SR 250L	K8002-420	-00-043-3947	K4-250-250L	-00-177-8967
5/16-18	M45932/1-19L	SR 318L	K8002-518	-00-376-8204 -01-139-3567	K4-318-318L	-00-157-1102
3/8-16	M45932/1-23L	SR 376L	K8002-616	-00-943-8157	K4-376-376L	-00-157-1103
7/16-14	M45932/1-27L	SR 434L	K8002-714	-00-420-5904	K4-434-434L	----
1/2-13	M45932/1-31L	SR 503L	K8002-813	-00-943-8159	K4-503-503L	-00-157-1104
9/16-13	M45932/1-35L	SR 562L	K8002-912	----	----	----
5/8-11	M45932/1-39L	SR 621L	K8002-1011	-01-113-5615	K4-621-621L	-00-157-1105
3/4-10	M45932/1-43L	SR 750L	K8002-1210	----	K4-750-750L	-00-157-1106
10-32	M45932/1-9L	SR 192L	K8002-3	-00-864-4959 -01-126-9532	K4-192-192L	-00-177-8968
1/4-28	M45932/1-13L	SR 258L	K8002-4	-00-814-0267	K4-258-258L	-00-178-0046
5/16-24	M45932/1-17L	SR 314L	K8002-5	-00-866-1327	K4-314-314L	-00-177-8962
3/8-24	M45932/1-21L	SR 374L	K8002-6	-00-019-9237	K4-374-374L	-00-157-1108
7/16-20	M45932/1-25L	SR 430L	K8002-7	----	K4-430-430L	-00-157-1110
1/2-20	M45932/1-29L	SR 500L	K8002-8	-00-943-8158	K4-500-500L	-00-157-1228
9/16-18	M45932/1-33L	SR 568L	K8002-9	----	----	----
5/8-18	M45932/1-37L	SR 628L	K8002-10	-01-114-0242	K4-628-628L	-00-157-1124
3/4-16	M45932/1-41L	SR 756L	K8002-12	-01-118-0711	K4-756-756L	-00-157-1130

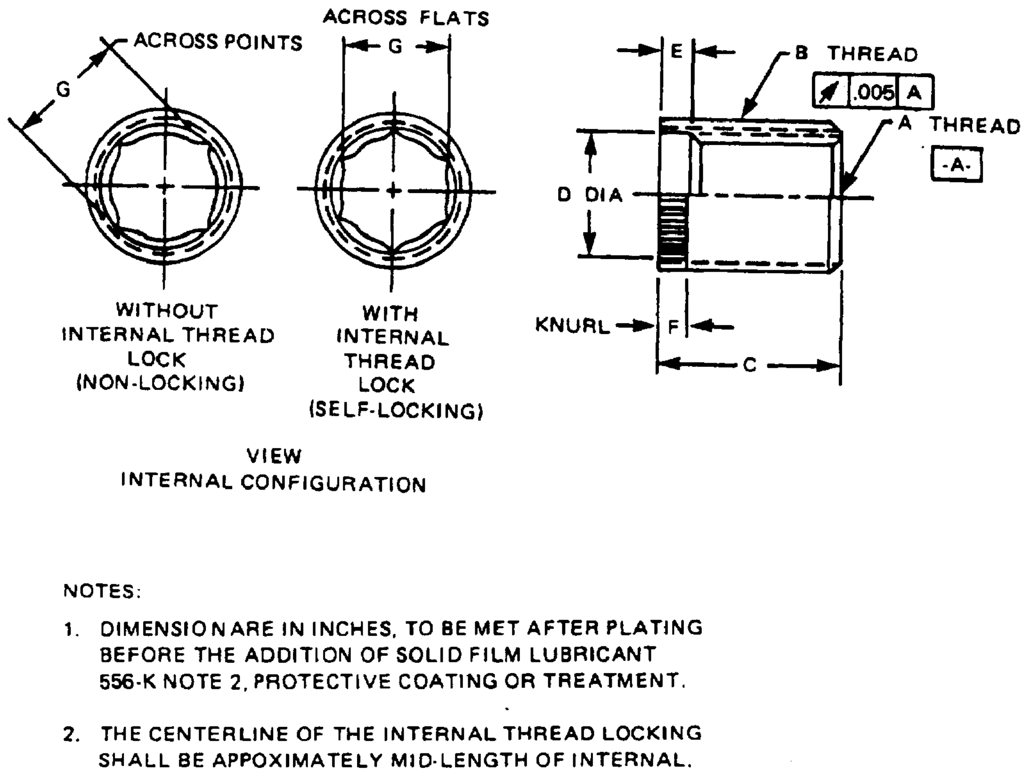


Figure 556-10-16 Insert Screw Thread

Table 556-10-15 OVERSIZE THIN WALL INSERTS, REPAIR KITS, AND NSN'S (THREAD LOCKING, 1-1/2 NOMINAL DIAMETER LENGTH, UNC AND UNF)

Insert Internal Thread Size	**Thin Wall Inserts with Internal Thread Lock***			**Repair Kits****	
	Military Number	**Rosan Num-ber**	**Insert NSN**	**Rosan Tool Kit**	**Insert & Tool Kit NSN**
6-32	M45932/3-5L	SRW 142L	5340-00-410-5851	K4SRW142-142L	----
8-32	M45932/3-7L	SRW 162L	5340-00-937-0534	K4SRW162-162L	----
10-24	M45932/3-11L	SRW 194L	5340-00-512-5049	K4SRW194-194L	5180-00-126-1722
1/4-20	M45932/3-15L	SRW 250L	5340-00-508-2071	K4SRW250-250L	5180-00-126-1766
5/16-18	M45932/3-19L	SRW 318L	5340-00-508-2081	K4SRW318-318L	5180-00-126-1761
3/8-16	M45932/3-23L	SRW 376L	5340-00-510-4603	K4SRW376-376L	5180-00-126-1750
7/16-14	M45932/3-27L	SRW 434L	----	K4SRW434-434L	----
1/2-13	M45932/3-31L	SRW 503L	5340-00-512-5008	K4SRW503-503L	5180-00-126-1773
10-32	M45932/3-9L	SRW 192L	5340-00-434-7575	K4SRW192-192L	5180-00-126-2797
10-32	M45932/3-9L	SRW 192L	5340-00-968-9432	K4SRW192-192L	5180-00-126-2797
1/4-28	M45932/3-13L	SRW 258L	5340-00-968-9433	K4SRW258-258L	5180-00-126-1769
5/16-24	M45932/3-17L	SRW 314L	5340-00-508-2079	K4SRW314-314L	5180-00-126-1765
3/8-24	M45932/3-21L	SRW 374L	5340-00-541-8928	K4SRW374-374L	5180-00-126-1759
7/16-20	M45932/3-25L	SRW 430L	5340-00-441-9051	K4SRW430-430L	5180-00-126-1701

Table 556-10-15 OVERSIZE THIN WALL INSERTS, REPAIR KITS, AND NSN'S (THREAD LOCKING, 1-1/2 NOMINAL DIAMETER LENGTH, UNC AND UNF) - Continued

Insert Internal Thread Size	**Thin Wall Inserts with Internal Thread Lock***			**Repair Kits****	
	Military Number	**Rosan Number**	**Insert NSN**	**Rosan Tool Kit**	**Insert & Tool Kit NSN**
1/2-20	M45932/3-29L	SRW 500L	5340-00-514-4184	K4SRW500-500L	5180-00-126-1774

Table 556-10-16 THIN WALL INSERT PART NUMBERS AND MATERIALS (Sheet 1 of 2)

Dash Numbers				A Int Thd Class 38 (Req 4)	B**Ext Thread Altered to Minor Dia		C**±.010	D**+.008 -.002	E**+.015 -.000	F**(Ref)	G**(Ref)	Min Shear Engage-ment Area (in^2) (Req 10)
17-4 PH CRES *	**Alloy Steel ***	**Beryl-lium Copper ***	**A-286 CRES ***		**Thread Size**	**Max Minor Dia**						
1 L	1 AL	1 BL	1 CL	.086-56 UNC	.086-56 UNF	.1073	.17	.086	.042	.032	.073	.0189
2	2 A	2 B	2 C				.13				.080	
3L	3 AL	3 BL	3 CL	.112-40 UNC	.164-32 UNC	.1380	.19	.116	.060	.050	.092	.0436
4	4 A	4 B	4 C								.100	
5 L	5 AL	5 BL	5 CL	.138-32 UNC	.190-32 UNF	.1620	.21	.142	.080	.055	.113	.0542
6	6 A	6 B	6 C								.120	
7 L	7 AL	7 BL	7 CL	.164-32 UNC	.216-28 UNF	.1890	.25	.169	.080	.055	.138	.0823
8	8 A	8 B	8 C								.150	
9 L	9 AL	9 BL	9 CL	.190-32 UNF	.250-28 UNF	.2170	.29	.192	.080	.075	.157	.1098
10	10 A	10 B	10 C								.180	
11 L	11 AL	11 BL	11 CL	.190-24 UNC							.157	
12	12 A	12 B	12 C								.180	
13 L	13 AL	13 BL	13 CL	.250-28 UNF	.3125-24 UNF	.2785	.38	.252	.095	.075	.210	.2037
14	14 A	14 B	14 C								.240	
15 L	15 AL	15 BL	15 CL	.250-20 UNC							.210	
16	16 A	16 B	16 C								.240	
17 L	17 AL		17 CL	.3125-24 UNF	.375-24 UNF	.3405	.47	.314	.110	.075	.266	.3306
18	18 A		18 C								.310	
19 L	19 AL		19 CL	.3125-18 UNC							.266	
20	20 A		20 C								.310	

Table 556-10-16 THIN WALL INSERT PART NUMBERS AND MATERIALS (Sheet 1 of 2) - Continued

Dash Numbers				A Int Thd Class 38 (Req 4)	B**Ext Thread Altered to Minor Dia		C**±.010	D**+.008 -.002	E**+.015 -.000	F**(Ref)	G**(Ref)	Min Shear Engage-ment Area (in^2) (Req 10)
17-4 PH CRES *	Alloy Steel *	Beryl-lium Copper *	A-286 CRES *		Thread Size	Max Minor Dia						
21 L	21 AL		21 CL	.375-24 UNF	.4375-20 UNF	.4010	.56	.377	.110	.105	.322	.4577
22	22 A		22 C								.370	
23 L	23 AL		23 CL	.375-16 UNC							.322	
24	24 A		24 C								.370	
25 L	25 AL		25 CL	.4375-20 UNF	.500-20 UNF	.4630	.66	.439	.135	.105	.377	.6522
26	26 A		26 C								.430	
27 L	27 AL		27 CL	.4375-14 UNC							.377	
28	28 A		28 C								.430	
29 L	29 AL		29 CL	.500-20 UNF	.5625-24 UNEF	.5290	.75	.505	.135	.105	.439	.8690
30	30 A		30 C								.490	
31 L	31 AL		31 CL	.500-13 UNC							.439	
32	32 A		32 C								.490	
33 L			33 CL	.5625-18 UNF	.6875-12 N	.6130	.84	.571	.145	.135	.481	1.1328
34			34 C								.550	
35 L			35 CL	.5625-12 UNC							.481	
36			36 C								.550	
37 L			37 CL	.625-18 UNF	.750-16 UNF	.6870	.94	.634	.145	.135	.534	1.4014
38			38 C								.620	
39 L			39 CL	.625-11 UNC							.534	

Table 556-10-16 THIN WALL INSERT PART NUMBERS AND MATERIALS (Sheet 1 of 2) - Continued

Dash Numbers				**A Int Thd Class 38 (Req 4)**	**B**Ext Thread Altered to Minor Dia**		**C**±.010**	**D**+.008 -.002**	**E**+.015 -.000**	**F**(Ref)**	**G**(Ref)**	**Min Shear Engage-ment Area (in^2) (Req 10)**
17-4 PH CRES *	**Alloy Steel ***	**Beryl-lium Copper ***	**A-286 CRES ***		**Thread Size**	**Max Minor Dia**						
40			40 C								.620	
41 L			41 CL	.750-16 UNF	.875-20 UNEF	.8240	1.12	.756	.170	.150	.648	2.0543
42			42 C								.750	
43 L			43 CL	.750-10 UNC							.648	
44			44 C								.750	

Table 556-10-16 THIN WALL INSERT PART NUMBERS AND MATERIALS (Sheet 2 of 2)

NOTES: 1. MATERIAL: Steel, alloy composition 4130 per AMS 6370. Steel, corrosion resistant, composition 17-4 PH per AM 5643. Steel corrosion resistant, composition A 286 per AMS 5734. Copper, beryllium per AMS 4650. 2. PROTECTIVE COATING OR TREATMENT: - Steel, alloy, shall be cadmium plated per QQ-P-416 type II class 2, plus solid film lubricant coating per MIL-L-8937, Form B. - Steel, corrosion resistant, composition 17-4 PH, shall be solid film lubricant coated per MIL-L-8937, Form B. - Steel, corrosion resistant, composition A-286, shall be silver plated per QQ-S-365 type II, grade B, .0002 thick min. - Copper, beryllium shall have a solid film lubricant coating per MIL-L-8937, Form B. 3. SURFACE ROUGHNESS: Machined surfaces shall be 125 microinches in accordance with ANSI B46. 1-1978 except knurling. 4. THREADS: Threads shall be in accordance with MIL-S-7742 except as noted in Table I and shall accept external MIL-S-8879 threads. All coarse internal threads have an increased minor diameter. Threads are prior to the addition of solid film lubricant. 5. HARDNESS: Alloy steel, Rockwell C25-34. Corrosion resistant steel, 17-4 PH, Rockwell C35-42. Corrosion resistant steel, A-286, Rockwell C32-40. Beryllium copper, Rockwell C25-34. 6. DIMENSIONS: All dimensions are in inches; to be met after plating and before the addition of solid film lubricants (See Requirement 2 herein). 7. PART NUMBERS: Part numbers consist of letter M plus the basic number of this specification sheet and a dash number taken from Table 1. Example: M 45932/1-9CL Insert, A286 CRES, self-locking M 45932/1-10C Insert, A286 CRES, non-locking 8. INTERNAL THREAD LOCKING FEATURE: The centerline of the internal thread locking feature shall be approximately mid-length of internal thread except - 1 size is located on a pilot at the bottom of insert. 9. PATENT: Inserts specified herein are manufactured under US patent No. 3,081.808 which expires 19 March 1980 and 3,190,169 which expires 22 June 1982. The Government does not have a royalty free license. 10. SHEAR ENGAGEMENT AREA: Shear engagement area is the assembled dimensional value for the overall engaged area of mating thread members. It does not represent a dimension of either of the members in an unassembled condition. (NOTES Concluded)

556-10.7.9.2 Thin Wall Insert Repair. In repair actions, if feasible, try to maintain the same bolt size and use the same type of insert originally installed. If threads are damaged it may be necessary to use a larger diameter insert but the same bolt size should be retained. Identification of all necessary parts to ensure the right combination for any repair action is beyond the scope of this manual. Some limited guidance is provided in the military specification slash sheets. For example, MIL-I-45432/1A and Table 556-10-17, provide bore dimensions for the insert and general requirements. Detailed instructions are provided in manufacturer's literature and repair kits for a specific bolt size contain all the necessary tools, drills, spare inserts, and instructions. When possible, use inserts that comply with military specifications and standards. Major manufacturers of thin-wall inserts and repair kits are Rosan Inc. for their Slimsert (Swage Type) and Ring-Locked inserts and Microdot products for their thin wall (Swage Type) and K-Sert (Key Type) inserts. Activities involved in the installation and repair of thin-walled inserts shall obtain a copy of technical manual **General Use of Rosan Fasteners, Fluid Fittings, and Criss Air Check Valves,** U. S. Air Forces T.O. 44H1-1-13, NAVAIR 01-1A-15.

Table 556-10-17 THIN WALL INSERT REPAIR (Sheet 1 of 2)

Nominal External Thread Size of Insert (Ref)	Insert Dash Number M 45932/1 (Ref)	Tap Drill Dia + .004 - .001	A CBORE DIA + .004 - .001	B CBORE Depth ±.005	C Thread Class-38 Altered Minor Dia	D Minimum Full Thread Depth	E Minimum Drill Depth Blind Hole	Insert Removal Drill Size (Note 6)
.138-40	1 2	.113	.138	.045-.050	.138-40 UNF	.160	.233	#30
.164-32	3 4	.140	.164	.052	.164-32 UNC	.220	.298	5/32
.190-32	5 6	.166	.187	.065	.190-32 UNF	.240	.318	#17
.216-28	7 8	.191	.216	.065	.216-28 UNF	.280	.369	#5
.250-28	9 10 11 12	.221	.250	.082	.250-28 UNF	.325	.414	15/64
.3125-24	13 14 15 16	.281	.312	.082	.3125-24 UNF	.415	.519	19/64
.375-24	17 18 19 20	.343	.375	.082	.375-24 UNF	.505	.609	23/64
.4375-20	21 22 23 24	.404	.437	.113	.4375-20 UNF	.595	.720	27/64
.500-20	25 26 27 28	.468	.500	.113	.500-20 UNF	.695	.820	31/64
.5625-24	29 30 31 32	.531	.562	.113	.5625-24 UNF	.785	.889	35/64

Table 556-10-17 THIN WALL INSERT REPAIR (Sheet 1 of 2) - Continued

Nominal External Thread Size of Insert (Ref)	Insert Dash Number M 45932/1 (Ref)	Tap Drill Dia + .004 - .001	A CBORE DIA + .004 - .001	B CBORE Depth ±.005	C Thread Class-38 Altered Minor Dia	D Minimum Full Thread Depth	E Minimum Drill Depth Blind Hole	Insert Removal Drill Size (Note 6)
.6875-12	33 34 35 36	.625	.687	.150	.6875-12 N	.873	1.081	41/64
.750-16	37 38 39 40	.703	.750	.156	.750-16 UNF	.967	1.123	47/64
.875-20	41 42 43 44	.844	.875	.156	.875-20 UNF	1.155	1.280	55/64

Table 556-10-17 THIN WALL INSERT REPAIR (Sheet 2 of 2)

NOTES: 1. Diameter A and thread shall be concentric within .006 T.I.R. 2. Axis of hole shall be normal to entry surface or provide spot face when required. 3. Machined surfaces shall be 125 micro inches in accordance with ANSI B46 1-1978. 4. Dimensions are in inches. 5. Install insert. (a) These inserts are primarily designed for use in aluminum, magnesium and other non-ferrous materials that do not exceed Brinnell 187 (3,000 kg load and 10-mm ball). Use in stainless steels, titanium, and hardened ferrous materials will normally require broaching serrations in counterbore to accept the insert knurls when swaging. (b) Use of insert manufacturer's wrench and swaging tool is mandatory. (Rosan Inc., Newport Beach, CA - FSCM 83324). (c) Install - 1 thru -8 inserts into hole until the top of inserts is .010 -.020 below boss surface and -9 thru -44 inserts .015 -.025 below boss surface. (d) Place swage tool in insert and apply a downward force sufficient to seat the tool shoulder against the boss surface which will effect full swageout and external lock setting. 6. Replacement of inserts is made with the same size inserts as those removed. Using removal drill size shown in Table 556-10-17, drill to depth B + .025. Then back out insert using installation wrench or a square type screw extractor. Remove loose chips, re-inspect hole and then re-install per note 5. (NOTES Concluded)

556-10.7.9.3 Installation of Insert. The first step is to prepare the tapped hole to accept the insert. This is the most important and most difficult step, and normally will be performed in the shop. The tap drill and thread tap shall be correct for the size insert to be installed. (See specification slash sheet or manufacturer's repair kit instruction for specific requirements.) For an original insert installation, use the step drill to achieve the required counterbore depth, then tap to the required minimum full thread depth. Screw the insert into the tapped hole using the appropriate wrench from the repair kit. When the shoulder of the wrench meets the surface of the parent material, the insert will be installed to the proper depth. Specification slash sheets identify the proper depth. To achieve external thread locking of the insert, which prevents the insert from unscrewing, it is necessary to expand the top serrated threads of the insert into the counterbored area. place the swage tool provided in the repair kit into the insert. With a hammer, apply a downward force sufficient to bottom the protective shoulder of the swage tool onto the surface of the parent material. This will effect full swage resulting in external lock setting. The last step, gauging the insert is optional. Insert the **G** (for go) end of the gauge into the neck of the insert. The gauge must bottom on the parent material surface to show that full swage has been accomplished. Next, insert the **N** (for no-go) end into the neck of the insert. The shoulder must be clear of the parent material surface to indicate that the insert has not been driven too deep (see Figure 556-10-9 for gauging).

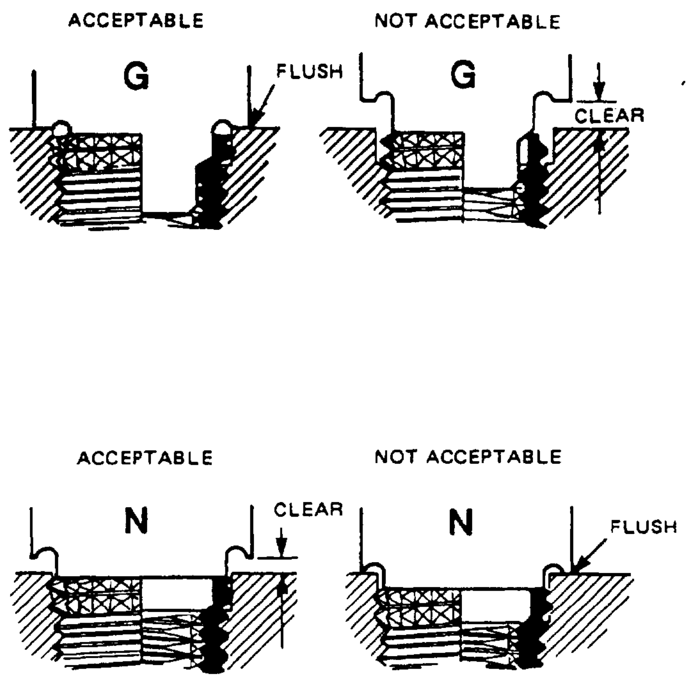


Figure 556-10-9 Gauging

556-10.7.9.4 Removal of Insert. To remove a thin wall insert from a tapped hole, the external locking must be eliminated. This is accomplished by drilling that portion of the insert which was swaged out (Figure 556-10-10). Using the appropriate removal tool from the repair kit, mill to depth of counterbore. Back out insert with drive wrench, clean out hole, and if the parent threads are good, install a new insert of the same size as the insert removed. Extensive damage to the parent threads will require redrilling, retapping, and the use of an oversize thin wall swage type insert.

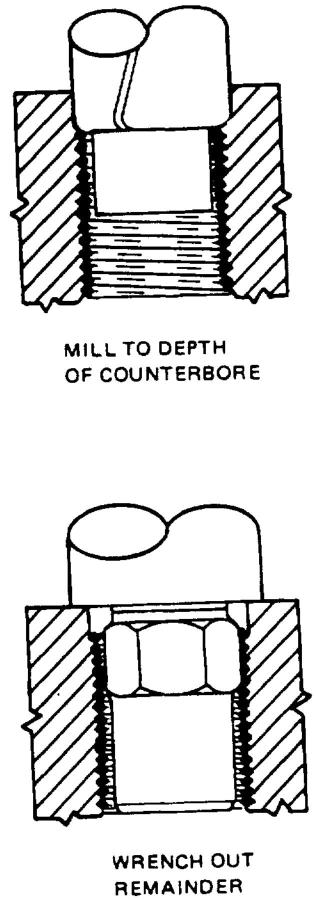


Figure 556-10-10 Removal of a Thin Wall Insert

556-10.7.9.5 Oversize Thin Wall Inserts. The oversize thin wall swage type insert is designed as a replacement for damaged helical wire-type inserts and complies with MIL-I-45932/3. In addition, these inserts will repair damaged holes in the parent material which originally specified thin wall swaged type inserts. Part numbers, materials and limited installation requirements are provided in MIL-I-45932/3, and also in Table 556-10-18. The installation instructions in paragraph 556-10.7.9.3 are applicable but should be supplemented by detailed instructions in the manufacturer's repair kit. Table 556-10-15 provides National Stock Numbers for some of the oversize thin wall swage type inserts and tool kits. Equivalent Rosan part numbers are also listed for identification of non-stocked sizes.

Table 556-10-18 OVERSIZE THIN WALL INSERTS (Sheet 1 of 2)

Dash Numbers*		**A** Int Thd Class 38 (Note 4)**	**B**Ext Thread Altered to Minor Dia**		**C** ±.010**	**D** + .008 - .002**	**E** + .015 - .000**	**F** (REF)**	**G** (REF)**	**Min Shear Engage-ment Area (in^2) (Note 5)**
17-4 PH CRES	**A-286 CRES**		**Thread Size**	**Max Minor Dia**						
3 L	3 CL	.112-40 UNC	.190-32 UNF	.1620	.190	.142	.060	.045	.092	.0439
4	4 C								.100	
5 L	5 CL	.138-32 UNC	.216-28 UNF	.1758	.210	.142	.080	.055	.113	.0542
6	6 C								.120	
7 L	7 CL	.164-32 UNC	.250-28 UNF	.2098	.250	.169	.080	.060	.138	.0871
8	8 C								.150	
9 L	9 CL	.190-32 UNF	.2812-28 NS	.2410	.290	.214	.080	.075	.157	.1147
10	10 C								.180	
11 L	11 CL	.190-24 UNC							.157	
12	12 C								.180	
13 L	13 CL	.250-28 UNF	.3438-24 NS	.2976	.380	.264	.095	.075	.210	.2153
14	14 C								.240	
15 L	15 CL	.250-20 UNC							.210	
16	16 C								.240	
17 L	17 CL	.3125-24 UNF	.4219-20 NS	.3651	.470	.336	.110	.075	.266	.3591
18	18 C								.310	
19 L	19 CL	.3125-18 UNC							.266	
20	20 C								.310	
21 L	21 CL	.375-24 UNF	.4844-20 NS	.4276	.560	.393	.110	.105	.322	.4938
22	22 C								.370	

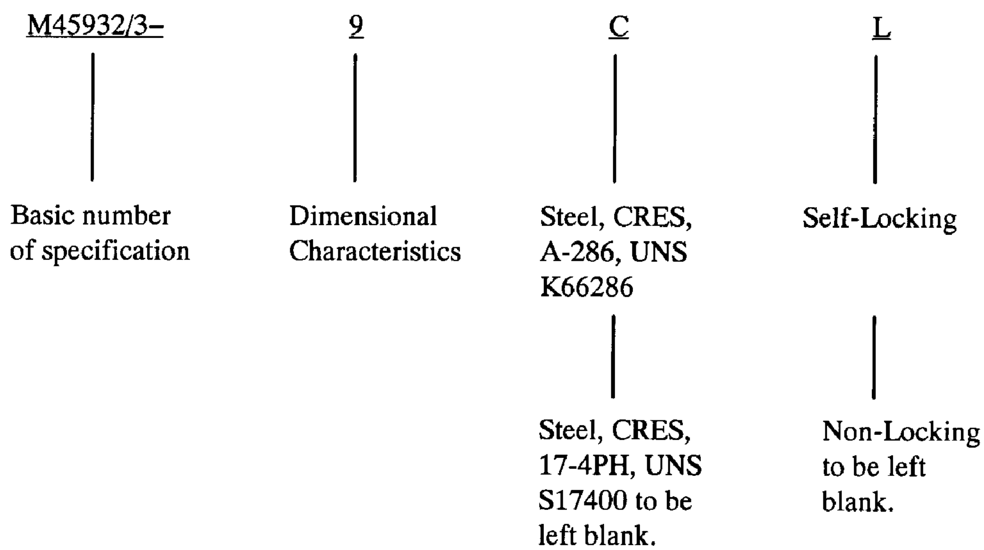
Table 556-10-18 OVERSIZE THIN WALL INSERTS (Sheet 1 of 2) - Continued

Dash Numbers*		**A** Int Thd Class 38 (Note 4)**	**B**Ext Thread Altered to Minor Dia**		**C** ±.010**	**D** + .008 - .002**	**E** + .015 - .000**	**F** (REF)**	**G** (REF)**	**Min Shear Engage-ment Area (in^2) (Note 5)**
17-4 PH CRES	**A-286 CRES**		**Thread Size**	**Max Minor Dia**						
23 L	23 CL	.375-16 UNC							.322	
24	24 C								.370	
25 L	25 CL	.4375-20 UNF	.5625-18 UNF	.4993	.660	.466	.135	.105	.377	.6714
26	26 C								.430	
27 L	27 CL	.4375-14 UNC							.377	
28	28 C								.430	
29 L	29 CL	.500-20 UNF	.625-18 UNF	.5618	.750	.528	.135	.105	.439	.8717
30	30 C								.490	
31 L	31 CL	.500-13 UNC							.439	
32	32 C								.490	
Refer to Figure 556-10-16										

Table 556-10-18 OVERSIZE THIN WALL INSERTS (Sheet 2 of 2)

NOTES:

1. Material: Steel, CRES, Composition 17-4 PH conforming to AMS 5643, Unified Numbering System, (UNS) S17400. Hardness, Rockwell C35-42. Steel, CRES, Composition A-286 conforming to AMS 5734, UNS K66286. Hardness, Rockwell C32-40.
2. Protective coating or treatment: Steel, UNS S17400 shall be coated with a solid film lubricant in accordance with MIL-L-8937, Form B. Steel, UNS K66286, shall be silver plated, .0002-inch thick minimum in accordance with AMS 2411.
3. Surface roughness: Machined surfaces shall be 125 microinches in accordance with ANSI B46.1-1978, expect Knurling.
4. Threads: Threads shall be in accordance with MIL-S-7742 except as noted in Table 556-10-18 and shall accept external MIL-S-8879 threads. All coarse internal threads have an increased minor diameter. Threads are before the addition of solid film lubricant.
5. Shear engagement area: Shear engagement area is the assembled dimensional value for the overall engaged area of mating thread members. It does not represent a dimension of either of the members in an unassembled condition.
6. Patent: Inserts specified are manufactured under U.S. Patent No. 3,081,808, which expires 19 March 1980 and 3,190,169, which expires 22 June 1982. The Government does not have a royalty-free license.
7. Military part number: Consists of the letter M, the basic number of the specification sheet, and a dash number taken from Table 556-10-18.
   Example of military part number:



556-10.7.9.6 Thin Wall Insert Repair Kits. Repair kits and inserts (locking and non-locking), as listed in Table 556-10-17 and Table 556-10-18 are available for a variety of popular sizes up to 3/4-inch thread size, UNF and UNC. Kits and inserts are also available from the manufacturer for metric threads. Each kit contains instructions and a quantity of both locking and non-locking inserts, a step drill, a tap, a four point wrench, a six point wrench, a swage tool, and a removal tool. Many stock numbers have been established for the different inserts and kits, and are provided in Table 556-10-17 and Table 556-10-18.

556-10.7.10 RING-LOCKED INSERTS. The ring-locked insert (Figure 556-10-11) complying with MS51991 is a heavier walled version of a thin wall insert with a different design to lock the insert external threads. Inserts are available with and without internal thread locking. The ring-locked insert is an internally and externally threaded sleeve whose basic function is to provide steel threads in weaker materials and, by virtue of the larger outside diameter, to provide increased bolt pull-out strengths. Although it is a stronger insert, it requires a larger space for the external thread and locking ring, and is more expensive. The distinguishing feature of ring-locked inserts is a serrated flange above the external threaded portion so configured as to mesh with the mating lock-ring. The lock-ring (Figure 556-10-12) provides complete anti-rotational security for the insert.

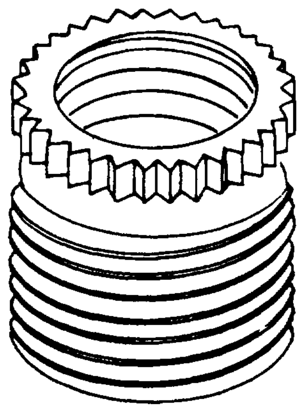


Figure 556-10-11 Basic Ring-Locked Insert

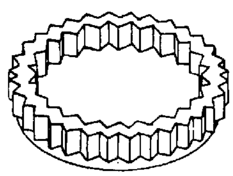


Figure 556-10-12 Lock-Ring

556-10.7.10.1 Lock-Ring. The lock-ring (Figure 556-10-12) is an accessory part used as an anti-rotation device for screw thread inserts, studs, and many other externally threaded fastening devices For MS 51991 inserts, the lock-ring is in accordance with MS 51990. It is serrated both internally and externally. The internal serrations are configured to mesh with those on the insert flange. The external serrations are relieved on the entering side so as to form a pilot to permit initial engagement internally. In addition, there is a 10-degree rake angle on the external serration so that the effect of a broach is duplicated when the ring is pressed or driven into the counterbored region in the receiving material. The crest of the serrations cut a series of longitudinal grooves, creating a composite shear area for resistance to rotation (Figure 556-10-13).

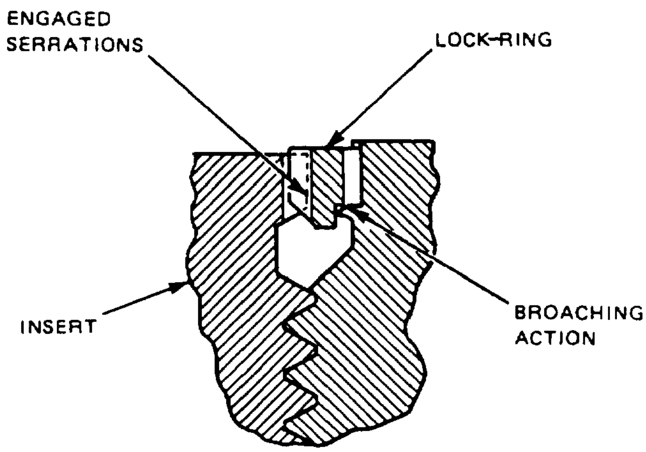


Figure 556-10-13 Ring-Locking Principle

556-10.7.10.2 High Strength Ring-Lock Inserts. This series of inserts comply with MS 51993 and use lock-rings per MS 51997. These inserts are not interchangeable with the standard ring-lock inserts, as the external threads are of different size and pitch. This series of parts is specially made to produce the greatest strength in as small an envelope as possible while retaining the ring-locked method, especially when used with NAS short thread bolts.

556-10.7.10.3 Repair Kits. A commercially available repair kit contains standard (MS 51991) ring-locked inserts and matching lock-rings. The kit contains complete preparation and installation tooling and instructions. For procurement of individual inserts and lock-rings, refer to MS sheets to identify standard part numbers.

556-10.7.10.4 Pre-Installation. Inspection is similar to inspection for other types of insert. The thread size and class of the removed bolt determines the removal drill to be used to remove the insert. Replacement of the insert may be required due to damage to the internal threads from cross threading or use of a different thread size bolt. Because of the high strength of these inserts, pullout or external thread damage of a properly installed insert is unlikely. Prepare hole in the parent material per applicable insert data sheet. Tap drilling and counterbore are performed in one operation by using a step drill, which also ensures concentricity. A standard Class 3 tap then completes the hole preparation. Gauging may be performed, using a standard Class 3 plug type gauge. Refer to specific manufacturer’s data for hole diameters in magnesium parent material. If the parent material surface is not normal to the hole axis, provide a spot face for proper lock-ring entry.

556-10.7.10.5 Installation. Inserts are installed by a specially designed manual wrench which engages the serrated flange of the insert. The wrench is hollow, and is made of hexagonal stock for a choice of wrenching methods. Inserts are installed so that the top of the serrated flange is from 0.010 to 0.020 below the material surface. This is very important so that the impact of the lock-ring drive tool cannot contact this surface and thus transmit any loads into the tapped threads of the parent material. The lock-ring is placed over the insert, undercut side down, and driven to a depth of 0.005 to 0.010 with the lock-ring drive tool. This tool, with pilot, features a raised driving face which controls the depth to which this lock-ring is driven. Make no attempt to drive the lock-ring any deeper. See Table 556-10-19.

556-10.7.10.6 Removal and Replacement. An insert to be removed is positioned on a drill press table and aligned with the spindle. With the appropriate removal drill, drill through the lock-ring and neck of the insert to destroy the serration interlock. Care must be exercised in that the drill must not progress beyond the depth of the counterbore in the parent material. Portions of the serrations still engaged will readily break away when removal torque is applied. Square screw extractors are generally used for this purpose. When the top threads meet the bottom surface of the lock-ring, continued removal torque will jack the ring out of the counterbore. If the lock-ring has been drilled completely through and fails to lift out with inserts, the remaining portion may be collapsed with a punch and removed. Replacement is made with an identical size insert, and in the same manner as for an original installation. The external serrations of the lock-ring, however, must be aligned with those already in the material.

Table 556-10-19 INSTALLATION REPLACEMENT CRITERIA

Nominal External Thread Size of Insert (Ref)	**Insert Dash Number M 45932/1 (Ref)**	**Tap Drill Dia + .004 - .001**	**A CBORE Dia + .004 - .001**	**B CBORE Depth ±.005**	**C Thread Class-38 Altered Minor Dia**	**D Minimum Full Thread Depth**	**E Minimum Drill Depth Blind Hole**	**Insert Removal Drill Size**
.190-32	3 4	.166	.187	.065	.190-32 UNF	.220	.298	#17
.216-28	5 6	.182	.216	.065	.216-28 UNC	.240	.329	#5
.250-28	7 8	.218	.250	.065	.250-28 UNF	.280	.369	15/64
.2812-28	9 10 11 12	.242	.281	.082	.2812-28 NS	.325	.414	17/64
.3438-24	13 14 15 16	.302	.343	.082	.3438-24 NS	.415	.519	21/64
.4219-20	17 18 19 20	.368	.422	.082	.4219-20 NS	.505	.630	13/32
.4844-20	21 22 23 24	.437	.484	.113	.4844-20 NS	.595	.720	29/64
.5625-18	25 26 27 28	.515	.562	.113	.5625-18 UNF	.695	.834	35/64
.625-18	29 30 31 32	.578	.625	.113	.625-18 UNF	.785	.924	39/64

556-10.7.11 KEY-LOCKED INSERTS. The key-locked insert (Figure 556-10-14, typical) is another type of thin wall insert, which complies with MS 51830 and MS 51831. Steps for hole preparation and installation are generally the same as other inserts, but the tools and dimensions are unique, particularly as applicable to the external thread locking feature. Briefly, drill the hole to the manufacturer's dimensions, screw in the insert with a special tool, and tap the locking keys in place using the reverse side of the installation tool and a hammer. Removal is also generally typical of other thin wall inserts, except for the locking area. Drill out the damaged insert to proper drill size and depth per manufacturer's details. Then deflect locking keys inward and break off.

Unscrew insert with a standard extractor type tool and replace with same size insert in the original hole. As with other inserts, if external thread or parent thread damages have somehow occurred, and assuming space is available, the use of the next larger size insert will result in the need for a larger bolt. It is preferable to retain the same size insert and original bolt size when repairs are made. If use of the next larger size insert is required, contact NAVSEA to determine whether other type inserts can be used to retain the original bolt size.

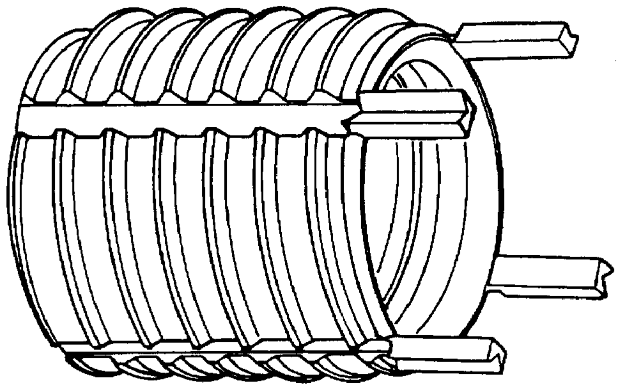


Figure 556-10-14 Key-Locked Insert (Typical)

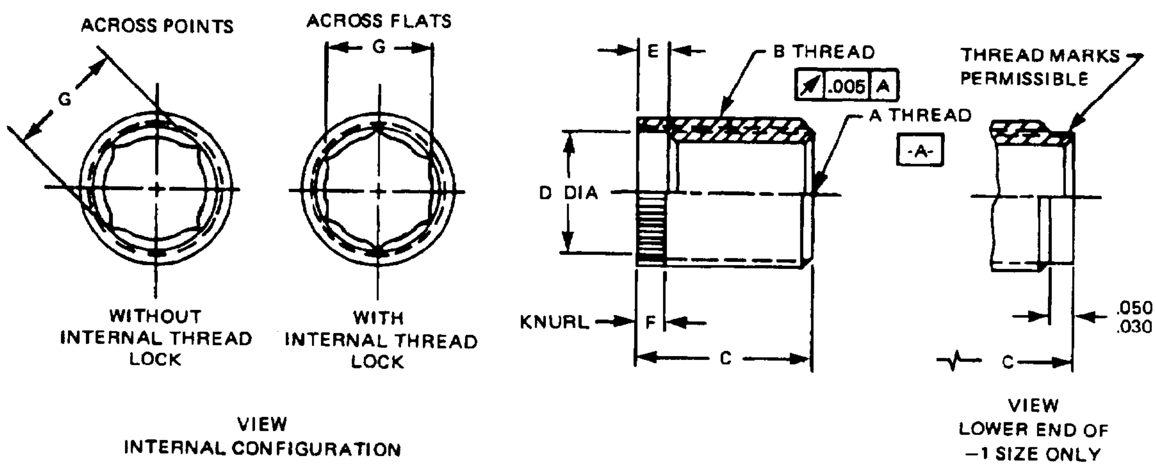


Figure 556-10-15 Thin Wall Insert

SECTION 11.

PACKING, GASKETS, AND O-RINGS

556-11.1 GENERAL

556-11.1.1 Materials for the wide variety of seal applications can be put into five general classifications: synthetic rubber, fluorinated compounds, silicones, fabric and rubber combinations, and leather. Selection of the most satisfactory material for O-rings, gaskets, or packing in a particular hydraulic application depends upon compatability with the hydraulic fluid, physical properties, and performance and endurance requirements. Included in these broad categories are considerations of such factors as resistance to heat and aging, pressure, low temperature flexibility, frictional properties, and wear. See **NSTM Chapter 078, Seals,** for a more detailed discussion of O-rings and other types of seals for hydraulic system equipment.

556-11.2 FLUID CONTAMINATION OF MIL-H-19457 SYSTEMS

556-11.2.1 Seals used in MIL-H-19457 systems are not necessarily compatible with petroleum oils or petroleum distillates (JP-5 diesel fuel, kerosene). When such petroleum-incompatible seals as butyl rubber and EPR (MIL-G-22050) are present, even small amounts of petroleum contamination can cause excessive swelling and premature failure of the seals. For example, MIL-H-19457 fluids normally cause butyl rubber and EPR to swell 6 percent, while a 2 percent oil contamination in MIL-H-19457 fluid causes these materials to swell 12 percent. A 10 percent oil contamination causes them to swell 42 percent. If MIL-H-19457 fluids became contaminated with petroleum oil or any other incompatible fluid, the contaminated fluid shall be removed as soon as possible, and seals inspected, as necessary, for possible degradation. Seals that have been removed for inspection must be replaced with new ones. In removal of the contaminated fluid, do not use petroleum distillates as a cleaning or flushing fluid. NAVSEA shall be advised when an incompatible fluid has contaminated MIL-H-19457 fluids so that an approved cleaning procedure can be provided.

556-11.3 HYDRAULIC SYSTEM SEAL LEAKAGE

556-11.3.1 LEAKAGE REQUIREMENTS. In general, newly-installed seals should not leak. With increasing age and wear, all seals can be expected to exhibit some leakage of fluid past the seal. Leakage occurs predominantly with dynamic (moving) seals; static (nonmoving) seals may last indefinitely without leaking if not disturbed. Leakage from external seals (where leakage is external to the component, such as the piston rod seal for a cylinder or a flange gasket) is most often detected visually, Usually, the most serious effect of this leakage is the oil accumulation and resultant housekeeping required. These seals should be replaced before leakage becomes bad enough to affect system operation. Leakage from internal seals (in which leakage is confined within the component such as the seals on a cylinder piston or valve sleeve) is difficult to determine and measure without conducting a test. Since the leakage is not visible, it is often undetected until it becomes bad enough to affect system operation significantly. Because seal replacement can require considerable time and labor, as well as depressurization of portions of the hydraulic system, unnecessary or premature action should be avoided. The leakage criteria provided below is intended for use as guidance when leakage requirements have not otherwise been provided. All dynamic leakage rates are based on a fluid temperature of 38°C (100°F). If the fluid temperature is lower than 38°C (100°F) during performance of the tests, a leakage correction factor should be applied. For relative leakage rates based on fluid viscosity see Section 4. If excessive leakage is measured at temperatures higher than 38°C (100°F), a retest with cooler fluid is recommended in lieu of applying leakage correction factors. For submarine hydraulic system accumulator dynamic leakage requirements, see Section 6; for specific guidance on vane-type and rack-and- pinion type actuator leakage, see Section 2. For submarine steering and diving hydraulic cylinders, acceptable dynamic leakage limits, as well as detailed test procedures to determine the leakage, are provided in **NSTM Chapter 561, Submarine Steering and Diving Systems.**

556-11.3.1.1 Static Seals. New seal installations in static applications should have zero leakage. Zero leakage means no oil transfer past the seal. Any dripping or weeping past the seal is generally considered unacceptable. Both new and old installations exhibiting dripping should be disassembled, inspected to identify corrosion, scoring, improper seal selection, seal degradation, or any other deficiency that may be responsible for the leak, and repaired as necessary. New installations that weep consistently should be analyzed on a case basis as planned deviations.

556-11.3.1.2 Dynamic External Seals. For newly installed seals, a slight wetting of the tailrod or other visible part of the sealing area is acceptable. A more specific acceptance criterion that may be used is the formation and dripping of 1 drop of fluid every 25 cycles for each inch of rod or seal diameter or fraction thereof. For example, a cylinder with a 2-1/4 inch tailrod would be allowed 3 drops of fluid per 25 cycles. A cycle for a cylinder is defined as operation from a fully retracted position to the fully extended position and back again to the fully retracted position, In many cases, housekeeping problems due to leakage may be the primary factor in determining whether or not seal replacement is necessary. If leakage occurs when the component is not operating, seal replacement should be initiated if the leakage exceeds four mL/hour for each inch of seal diameter or fraction thereof. If leakage primarily occurs during cycling of the component a leakage rate in excess of one mL per inch of rod or seal diameter or fraction thereof for every ten cycles may be used as a criterion for replacement.

556-11.3.1.3 Dynamic Internal Seals. In the case of piston seals and similar internal applications, minor leakage is not detrimental. However, an increase in leakage is an early warning of impending seal problems. Leakage criteria should be selected that will result in seal replacement before serious failure of the seal occurs. When new seals are installed there should be almost no leakage across the seal, particularly if the component is not operating. However, cylinders that are scored or otherwise worn or damaged may exhibit some leakage. Therefore the recommended maximum acceptable leakage is one mL per 10 minutes per inch of seal diameter for new installations. With use, internal seal leakage is allowed to increase to 5 mL per 5 minutes per inch of seal diameter or fraction thereof with the test pressure as practical. These leakage limits for internal dynamic seals are applicable to measurements made under static test operating conditions, which is usually the only way most operating components can be checked for internal leakage. For example, to measure the leakage across a cylinder piston seal, the cylinder would be pressurized to bottom the piston at one end of the cylinder With the unpressurized side of the cylinder isolated from the rest of the system, fluid leakage for the pressurized side across the seal could be measured via a cylinder vent or drain fitting.

REAR SECTION

NOTE

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